Comments of the Manufacturers of Emission Controls Association on the U.S. Environmental Protection Agency's National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines Proposed Rulemaking

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The Manufacturers of Emission Controls Association (MECA) is pleased to provide comments in response to the U.S. Environmental Protection Agency's National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines Proposed Rulemaking. We commend the agency for its continuing efforts to develop and implement effective emission control standards for major sources of air pollution such as this category of engines.

MECA is a non-profit association made up of the world's leading manufacturers of emission control technology for automobiles, trucks, buses, and off-road equipment, as well as stationary internal combustion engines. MECA member companies have over 35 years of experience and a proven track record in developing and commercializing exhaust emission control technologies for these types of engines.

Introduction

The proposed rulemaking sets emission standards for hazardous air pollutants (HAPs) from existing stationary engines through limits on formaldehyde and carbon monoxide (CO) emissions as surrogates for HAPs. The emission control technologies that are being considered to reduce these HAP and CO emissions are commercially available and proven technologies that provide important multi-pollutant co-benefits. Specifically, catalyzed diesel particulate filters and diesel oxidation catalysts, both of which can effectively reduce HAP and CO emissions from existing stationary diesel engines, provide the co-benefit of reducing emissions of particulate matter (PM). Furthermore, diesel particulate filters can significantly reduce emissions of black carbon, a pollutant that many scientists and health experts believe is the second largest contributor to global warming after carbon dioxide. And, for existing stationary rich-burn engines, non-selective catalytic reduction (NSCR), the emission control technology that EPA expects to be used to meet the proposed HAP limits for these engines, provides the co-benefit of reducing emissions of oxides of nitrogen (NOx). Given the well-documented environmental and health benefits of reducing emissions of PM and NOx, these multi-pollutant co-benefits are significant.

Available Emission Control Technologies for Existing Stationary Diesel Engines

The main technologies that have been successfully used to reduce diesel particulate matter (PM) from stationary diesel-fueled engines are diesel particulate filters and diesel oxidation catalysts. Flow-through filters can also be used to reduce diesel PM from stationary diesel engines.

Diesel particulate filters (DPFs) have been successfully used in many stationary applications, including prime stationary and emergency standby engines. The key component of a DPF is typically a porous ceramic wall-flow material (or sintered metal material), which permits gases in the exhaust to pass through but traps the PM. PM emission reductions in excess of 85 percent are possible, depending on the engine's baseline emissions, fuel sulfur content, and duty cycle. In addition, up to a 90 percent reduction in carbon monoxide (CO) and a 95 percent reduction in hydrocarbons (HCs) can also be realized with catalyst-based DPFs operated on ultra-low sulfur diesel fuel. DPFs will also remove all heavy metals, unless they are volatile (e.g., mercury). These non-volatile metallic HAPs will be collected by the filter as part of the unburned ash.

Since DPFs will accumulate soot over time, they must be cleaned out ("regenerated") intermittently. Both passive (DPF systems that regenerate using available exhaust heat and/or the oxidation of available engine-out NO to NO_2, a powerful oxidizing agent for trapped carbon) and active (DPF systems that use additional energy inputs to facilitate regeneration, such as diesel fuel injection strategies, engine throttling strategies, the use of electrical heating elements, or fuel burners) techniques can be used. In addition, the use of a fuel-borne catalyst (FBC) in conjunction with uncatalyzed or lightly catalyzed DPF systems can help provide reliable filter regeneration, especially at lower exhaust temperatures and/or elevated fuel sulfur levels.

Diesel oxidation catalysts (DOCs) are another important emission control strategy for reducing pollution from stationary diesel engines. Typically using a very light loading of platinum catalyst on a monolithic support, they are able to oxidize CO, HC, and the soluble organic fraction (SOF) of PM in a diesel engine's exhaust stream. DOCs installed on engines running 500 ppm or less sulfur fuel have achieved total particulate matter reductions of 20 to 50 percent, HC reductions of 60 to 90 percent (including those HC species considered toxic, e.g., polyaromatic hydrocarbons), and significant reductions of CO, smoke, and odor. (Note: Oxidation catalyst technology has also been widely used on stationary lean-burn natural gas engines. As noted by EPA in the proposed rulemaking, oxidation catalysts can achieve significant reductions in HAP and CO emissions cost-effectively from these engines.)

Flow-through filter (FTF) technology is another available method for reducing diesel PM emissions from stationary diesel engines. FTFs employ catalyzed metal wire mesh structures or tortuous flow, metal foil-based substrates with sintered metal sheets to reduce diesel PM. Technologies verified to date employ catalyst coatings and/or fuel-borne catalysts to oxidize soot. Flow-through filters are capable of achieving PM reductions of about 30 to 75 percent. The filtration efficiency of an FTF is lower than that of a DPF, but the FTF is much less likely to plug under unfavorable conditions, such as high PM emissions and low exhaust temperatures. To function effectively, FTFs must also incorporate an effective passive or active regeneration strategy for captured PM, similar to high-efficiency DPFs.

In addition to PM emissions from a stationary diesel engine's exhaust stack, PM emissions from the engine's crankcase can be substantial (as much as 0.7 g/bhp-hr PM during idle conditions). To control these emissions, closed crankcase ventilation (CCV) systems can be installed, which return the crankcase blow-by gases to the engine for combustion. CCV systems prevent oil-mist fouling of radiators, the engine compartment, and the general area around the stationary engine. CCV systems virtually eliminate crankcase PM emissions (over 90 percent) during all engine-operating modes. The CCV system consists of a filter housing with a disposable filter that must be periodically replaced, a pressure regulator, a pressure release valve, and an oil check valve. Verified CCV systems are typically installed with either a DPF or a DOC.

Diesel PM emission reductions can also be realized through the use of cleaner diesel fuels, biodiesel, or alternative fuels. The use of ultra-low sulfur diesel (ULSD) fuel can result in modest PM reductions by itself and will enable the optimum use of advanced emission control technologies (e.g., catalyst-based DPFs, catalyst-based FTFs, and DOCs). EPA has already finalized rules that require the use of ULSD on off-road diesel engines starting in 2010. The use of ULSD on stationary diesel engines, however, is only currently required for those stationary engines that are constructed, reconstructed, or modified after July 11, 2005. As part of this present rulemaking effort, MECA believes that EPA should require all stationary diesel engines to operate on ULSD no later than the 2010 requirement associated with off-road diesel engines.

Feasibility of Emission Control Technologies for Existing Stationary Diesel Engines

Based upon current real-world experience, results from demonstration programs, and conversations with MECA member companies, MECA believes that exhaust emission controls are a proven technology option for reducing emissions from in-use stationary diesel engines, including older (manufactured before 1996) and large (300 hp and greater) in-use stationary diesel engines. One of the key sources of information in support of the technical feasibility of applying emission controls to stationary diesel engines is the work conducted by the California ARB in support of its airborne toxic control measure (ATCM) for stationary compression-ignition engines (promulgated in November 2004). In the ATCM, diesel retrofits are one of the compliance options identified for reducing PM emissions from existing stationary diesel engines used in prime applications and emergency stand-by applications.

This ATCM requires in-use stationary diesel engines >50 hp used for either prime applications or emergency stand-by applications (operated for 51-100 hours/year) to meet a 0.01 g/bhp-hr PM standard or to reduce PM emissions by 85 percent or more by no later than January 1, 2009 for 1996 or older engines (or by January 1, 2008 for owners of three or fewer engines). Level 3 (at least 85 percent or greater PM reduction) verified retrofit technologies, such as verified DPFs, provide the required PM reductions to meet these ARB ATCM requirements. (Note that California requires all stationary diesel engines to be fueled with ultra-low sulfur diesel fuel with a maximum sulfur content of 15 ppm.) For both small (≤50 hp) and larger engines (>50 hp), ARB determined that the PM emission standards under the ATCM were technologically feasible due to: 1) successful emission control experience with similar-sized off-road engines that had to meet the same PM standards and 2) successful operation of approximately 50 stationary diesel-fueled engines with DPFs in California (the engines controlled represent a wide range of engine types, model years, horsepower ratings, and applications).

As of May 2009, there are seven different Level 3 DPF systems (both actively and passively regenerated) and one Level 2 (at least 50 percent or greater PM reduction) FTF system that have been verified by ARB for stationary engines. (A complete listing of ARB-verified retrofit technologies for stationary diesel engines is available at: www.arb.ca.gov/diesel/verdev/vt/stationary.htm.) Additional verifications of retrofit DPF technologies for stationary engines are expected in the future. Although no technology has been verified by ARB for stationary diesel engines older than 1996, it should be noted that one Level 2 technology is currently verified for use on stationary diesel engines with a PM emission rate of up to 0.4 g/bhp-hr, a PM level which is characteristic of older stationary diesel engines. In addition, two Level 3 technologies have previously been verified for use on up to 0.4 g/bhp-hr PM engines.

As EPA is aware, ARB and EPA have also verified a large number of Level 3 DPF technologies for mobile on-road and nonroad applications (a complete listing of ARB-verified retrofit technology – Levels 1-3 – for mobile source applications is available at: www.arb.ca.gov/diesel/verdev/vt/cvt.htm; EPA's list of verified retrofit technology products is available at: www.epa.gov/otaq/retrofit/verif-list.htm). In many cases, similar types of DPF retrofit solutions for mobile nonroad sources can be engineered for many existing stationary diesel engine applications.

In discussions with MECA member companies, the important design parameters to consider when determining the feasibility of installing a PM emission control system on a particular existing stationary diesel engine include:

- the substrate volume (which is tied in part to the engine-out PM levels and engine backpressure limits),
- the operating cycle/engine operating temperature (the temperature must be hot enough to ensure regeneration of the collected soot if using a passive regeneration strategy; otherwise, an active regeneration strategy may be necessary),
- the NOx-to-PM ratio of the engine exhaust stream (typically, a minimum of 16, with an optimum ratio of 20; this is a particularly important consideration if using a passive regeneration strategy), and
- the amount of lube oil consumed (too much lube oil will require more frequent cleaning of the filter).

(Note: For uncertified stationary diesel engines (i.e., pre-1996), if NOx and PM engine-out data are not available, most emission control technology suppliers would typically recommend the use of a DOC to reduce HAP and PM emissions since measurements needed to determine the NOx-to-PM ratio can be cost-prohibitive.

Typically, older stationary diesel engines have a very high SOF content, so a DOC would be appropriate.)

For emission control systems that make use of a catalyst, technology providers can formulate the catalyst to maximize the reduction of HAPs. One MECA member has stated that, in direct support of this proposed rulemaking, they will be optimizing the catalyst used in their emission control devices for both stationary gas and diesel engines to achieve maximum HAP reduction (especially formaldehyde). To avoid warranty claims (especially in California where the ARB warranty requirements for verified retrofit devices are more stringent than EPA's warranty requirements), suppliers of PM emission control technology – namely, DPF suppliers – are extremely diligent in ensuring that their devices will be effective in removing PM from the diesel engine on which they are installed.

Regarding the potential increase of NO_2 emissions as a result of using catalyzed emission control devices (such as DPFs, FTFs, and DOCs) on stationary diesel engines, all emission control devices currently verified by both EPA and ARB for mobile and stationary diesel engines meet an NO_2 limit of no more than 20 percent of the baseline engine NO_2 levels. MECA member companies and MECA staff worked closely with both ARB and EPA over the past several years to address the potential health and environmental issues of NO_2 and to develop this NO_2 limit. (ARB amended their retrofit verification procedure in March 2006 requiring that, effective January 1, 2007, verified diesel emission control systems must not increase NO_2 emissions by more than 30 percent of the baseline NOx and by no more than 20 percent from January 1, 2009. EPA followed suit in December 2007, announcing alignment with ARB's 20 percent NO_2 requirement effective on January 1, 2009.)

Experience with Retrofitting Existing Stationary Diesel Engines

The most comprehensive information on the application of PM exhaust emission control technology to in-use stationary diesel engines can be found in ARB's September 2003 Staff Report in support of its ATCM for stationary compression-ignition engines. In the report, ARB provides a thorough list of in-use emergency standby engines and prime stationary engines using emission control systems (mostly DPFs) in California. The retrofit devices were installed on stationary engines ranging from model years 1993 to 2002. The list shows numerous DPF installations on large engines rated above 600 kW, including Caterpillar 3516 engines rated in the 1490-2120 kW range. Operating experience with these large engine DPF systems has been generally good, with DPFs providing 85 percent or more reductions in particulate matter compared to uncontrolled levels. ARB interviewed several of the stationary engine operators and most stated that the retrofit devices met all regulatory requirements and required little or no extra maintenance.

One MECA member company estimates that there are approximately 750 stationary diesel engines in California that currently use some form of PM emission control technology (i.e., DPFs and DOCs). The vast majority of these engines are in-use emergency standby engines (around 720), with the rest being prime stationary engines.

In July 2005, the California Energy Commission published a report, *Air Quality Implications of Backup Generators In California*, detailing the emission performance of back-up diesel generators with a variety of power ratings equipped with exhaust emission controls, including DOCs, passive DPFs, and active DPFs (a copy of this report is available at: www.energy.ca.gov/2005publications/CEC-500-2005-049/CEC-500-2005-049.PDF). The DPFs evaluated in this program were found effective in reducing PM emissions by more than 85 percent compared to uncontrolled baseline levels. The results of the demonstration program showed successful application of DPFs, DOCs, and emulsified fuels on engines ranging in age from two to 18 years old. Durability testing of the DPF and DOC systems for intermittent cold start and extended high load operation indicates that these technologies are effective for generator applications and may be effective for other steady-state stationary engine applications as well.

Several MECA member companies have experience with the application of DPFs to existing stationary diesel engines. DPFs have been successfully applied to stationary engines as small as 20 kW to very large installations on emergency back-up or prime power generators with several megawatts of power. This experience base includes both passively regenerated DPF systems and actively regenerated DPF systems, as well as fuel-borne catalyst regenerated DPF systems.

Highlighted below are specific examples of emission control systems installed on existing stationary diesel engines by MECA member companies:

- In July 2007, Janssen Ortho, a subsidiary of Johnson & Johnson, located in Gurabo, Puerto Rico, installed DPF+SCR systems on three 2220-hp Cummins KTTA50-G2 engines (approximately 0.2 g/bhp-hr PM). The engines are used to provide emergency backup power for their pharmaceutical R&D and manufacturing facility. Despite the limited amount of space around the engines, the company and emission control technology provider worked together to arrive at a compact and efficient solution – a platform design that allowed all of the emission control equipment to be installed above the engines. The DPF+SCR systems achieve PM reductions of >90 percent and NOx reductions of 91-92 percent.
- In September 2005, J. Cloud Inc., a rock-crushing operation in El Cajon, California, installed DPF systems on their pre-1996 Caterpillar 3408 (0.2 g/bhp-hr PM) and Caterpillar 3306 (0.3 g/bhp-hr PM) engines. The 536-hp Caterpillar 3408 engine drives a hydraulic pump that powers a rock crusher and the 430-hp Caterpillar 3306 engine drives a generator that provides power for a conveyor. Each DPF system contains two filters and each was designed to match the engine size and exhaust conditions of the respective engine. The site operates eight hours a day for five days a week. The DPF systems have achieved PM reductions of 85 percent and CO reductions of 80 percent. In addition, the DPF systems run at a backpressure of approximately 15” water

column at full load and have only been cleaned once at 1,200 hours to remove accumulated ash from the filters.

- In September 2003, Snow Summit Ski Resort in Big Bear Lake, California, installed DPF+SCR systems on two large stationary engines. The two engines are Cummins QSK78-G6 diesel engines (0.2 g/bhp-hr PM), which power two 2-MW generators. The generators are used to operate snow-making and other auxiliary equipment. Source test results showed PM reductions of greater than 90 percent and NOx reductions of greater than 94 percent.

One MECA member company has had extensive experience with the retrofit of stationary diesel engines in Taiwan. Power outages are frequent in Taiwan, so standby generators used for emergency back-up power are an important part of the country's infrastructure. DPFs have been successfully installed on these generators. For example, Taiwan Semiconductor Manufacturing installed DPFs on 14 standby generators (2 MW engines) in 2001, which has resulted in a greater than 90 percent reduction in PM.

In terms of retrofit experience in the mobile sector that can be applied to stationary engines, there is a wealth of experience where DPFs have been cost-effectively installed on nonroad vehicles. DPFs have been successfully installed and used on mining, construction, and materials handling equipment where vehicle integration has been challenging. These nonroad applications include the use of both passive and active filter regeneration strategies. Over 20,000 active and passive systems have been installed on nonroad applications as either original equipment or as a retrofit worldwide. DPFs, many employing active regeneration strategies, have also been installed on over 100 locomotives in Europe since the mid-1990s.

The retrofit of oxidation catalysts on diesel engines has been taking place for well over twenty years in the nonroad vehicle sector. Over 250,000 oxidation catalysts have been installed in underground mining and materials handling equipment. DOCs have also been installed in marine diesel applications (e.g., ferries), which have duty cycles that closely mimic stationary engine operation.

Regarding experience with installation of closed crankcase ventilation systems on existing stationary diesel engines, one MECA member company reported that one manufacturer of CCV systems has been selling them for stationary diesel engines since the mid-1990s. On the mobile-source side, CCV systems have been successfully retrofit on a variety of diesel vehicles, including school buses, transit buses, and port trucks. In addition, EPA's 2007 highway diesel rule and Tier 4 regulations for nonroad diesel engines require that engine manufacturers employ crankcase emission controls on all new diesel engines.

Costs of Retrofitting Existing Stationary Diesel Engines

As part of their September 2003 stationary CI engine ATCM staff report, ARB conducted an economic analysis to determine the cost to businesses to meet the ATCM. ARB concluded that the majority of the costs would be borne by prime engine owners, while, in many cases, owners of emergency standby engines would have no cost or net savings due to the reduced operating hours. The total costs for a typical prime stationary engine (rated at 590 hp operated for 1,040 hours per year) retrofitted with a DPF were about $22,400 for equipment and installation, $100 for reporting, and $550 per year for ash cleaning/maintenance. The total cost for the same engine with a DOC was about $6,250 (no annual maintenance). ARB estimated the overall cost-effectiveness of the proposed ATCM to be about $15 per pound of diesel PM reduced, considering only the benefits of reducing PM. However, since the ATCM would also reduce reactive organic gases (ROG) and NOx emissions, ARB staff allocated half of the costs of compliance against these benefits, which resulted in cost-effectiveness values of $8/lb of PM and $1/lb of ROG plus NOx reduced.

Although diesel PM is not included on the list of EPA's hazardous air pollutants, EPA considers diesel PM to be a serious public health concern and a possible carcinogen. Given that approximately 30 percent of diesel PM is made up of soluble organic fraction (SOF) and given that the SOF consists of condensed volatile compounds, many of which are on the HAP list, it is important to consider the multi-pollutant co-benefits that emission controls can provide in reducing CO, formaldehyde, HCs, and SOF. An inexpensive device such as a DOC can effectively remove the SOF from the carbon particles, offering significant HAP benefits at a reasonable cost.

Black Carbon Emissions from Existing Stationary Diesel Engines

Black carbon is a major component of PM emissions from fossil fuel-burning sources and is believed to have a significant net atmospheric warming effect by enhancing the absorption of sunlight. Since black carbon particles only remain airborne for weeks at most compared to carbon dioxide, which can remain in the atmosphere for more than a century, removing black carbon would have an immediate benefit to both global warming and public health.

Black carbon from stationary diesel engines can be significantly reduced through emission control technology that is already commercially available. As discussed earlier, high-efficiency DPFs on new and existing diesel engines provide nearly 99.9 percent reductions of black carbon emissions. During the regeneration of DPFs, captured carbon is oxidized to CO_2, but this filter regeneration still results in a net climate change benefit since global warming potential of black carbon has been estimated to be up to 4500 times higher than that of CO_2 on a per gram of emission basis.

Since EPA's latest set of emission standards for new diesel engines (i.e., light-duty, on-road heavy-duty, nonroad heavy-duty, commercial marine, and locomotive engines) have set technology-forcing PM standards that will largely be met through the use of DPFs, EPA should determine effective policies for encouraging or requiring the use of DPFs on all existing diesel engines, including stationary diesel engines, as a means of not only providing health-based benefits but also climate change benefits associated with black carbon reductions.

Emission Control Technologies for Existing Stationary Rich-Burn Engines

MECA agrees with EPA's analysis that the use of non-selective catalytic reduction (NSCR) technology is a cost-effective means to reduce HAP and NOx emissions from existing stationary rich-burn engines. NSCR is a proven technology that has been installed on thousands of rich-burn engines. In addition, several MECA member companies have verified retrofit NSCR systems with ARB for use on large, spark-ignited off-road engines (engines 25 hp or greater) to reduce NOx, HCs, and CO. These verified systems can be used on existing stationary rich-burn engines as well. (A complete list of ARB-verified retrofit technologies for large, spark-ignited off-road engines is available at: www.arb.ca.gov/msprog/offroad/orspark/verdev.htm.)

Additional Considerations

Although the main focus of our comments has been on the benefits of emission control technology to reduce PM emissions from existing stationary diesel engines, MECA would like to recommend that EPA also consider the benefits of using selective catalytic reduction (SCR) technology to reduce both HAP and NOx emissions from both stationary diesel engines and stationary lean-burn natural gas engines. As noted by EPA in the proposed rulemaking, existing stationary engines (both rich-burn and lean-burn stationary engines) emit significant amounts of NOx emissions. Stationary diesel engines in particular emit 620,000 tons per year of NOx. Retrofit SCR systems can reduce NOx emissions from existing stationary diesel engines by 80 percent or more. In addition, since retrofit SCR systems typically incorporate the use of a diesel oxidation catalyst, these SCR systems can also reduce HAP emissions as well.

SCR has long been the technology of choice for NOx emission reduction in industrial processes and stationary power generation applications. The commercial use of SCR systems for the control of NOx from stationary engines has been around since the mid-1980s in Europe and since the early 1990s in the U.S. Since 1995, one MECA member company specifically has installed over 400 SCR systems worldwide for stationary engines with varying fuel combinations. More recently, cost-effective SCR systems have been developed for mobile source applications, including heavy-duty trucks, light-duty vehicles, off-road equipment, marine engines, and locomotives. 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.

Conclusion

We commend EPA for taking an important step to reduce emissions from existing stationary internal combustion engines. In particular, we believe the current real-world experience and results from demonstration programs indicate that diesel PM control technologies are capable of providing a wide range of reduction levels for existing stationary diesel engines.

DPFs, in particular, have demonstrated to be very effective in reducing PM emissions from both mobile and stationary diesel engines. The combination of using ultra-low sulfur diesel fuel with high-efficiency DPFs (e.g., DPFs that use wall-flow ceramic filters) provides the maximum reduction in PM emissions, including black carbon emissions, and additional significant reductions in toxic HC emissions and CO when catalyst-based DPFs are employed. MECA believes DPFs should be installed on in-use stationary diesel engines wherever technically feasible and that these engines should be fueled with ultra-low sulfur diesel fuel to provide the maximum flexibility in the design of effective retrofit DPF emission control solutions. MECA believes that the use of ULSD in combination with retrofit DPFs on existing stationary diesel engines can be implemented in the 2010 timeframe on both prime and emergency stand-by engines with power ratings of 50 hp or greater. In addition, the combination of DPFs with SCR systems can be an effective solution for delivering combined PM and NOx reductions from in-use stationary diesel engines. In situations where DPFs are not technologically feasible, DOCs should be considered as an alternative option to help achieve at least a minimum level of PM control from applicable stationary diesel engines.

MECA and its member companies look forward to working with EPA, the engine and equipment manufacturers, end-users, and others in implementing this proposed rulemaking.

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