COMMENTS OF THE MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION ON THE SOUTH COAST AIR QUALITY MANAGEMENT DISTRICTS PROPOSED AMENDMENTS TO RULE 1470: REQUIREMENTS FOR STATIONARY DIESEL-FUELED INTERNAL COMBUSTION AND OTHER COMNPRESSION IGNITION ENGINES

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The Manufacturers of Emission Controls Association (MECA) is pleased to provide these comments in support of the amendments to Rule 1470 proposed by the South Coast Air Quality Management District. We commend the agency for its continuing efforts to develop and implement effective emission control standards for major sources of air pollution such as new and in-use stationary diesel-fueled internal combustion and other compression ignition engines.

MECA is a non-profit association made up of the world's leading manufacturers of emission control technology for mobile and 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 a wide range of new original equipment and in-use on-road and off-road vehicles and engines of all sizes including stationary compression ignition engines used for prime power and emergency standby power generation. MECA member companies are committed to ensure that the emission control technologies to achieve the emission targets of this rule are available.

Introduction

The proposed changes to Rule 1470 set health based PM limits for new emergency standby engines that require PM exhaust emission controls for engines less than or equal to 100 meters from a sensitive receptor and risk levels established by Rule 1401 for engines beyond 100 meters of sensitive receptors. The emission control technologies, such as wall flow diesel particulate filters (DPFs) that are being considered to reduce PM emissions near sensitive receptors are commercially available and proven technologies that provide important multi-pollutant co-benefits in addition to PM reductions of greater than 85% or 0.01 g/bhp-hr. Specifically, catalyzed diesel particulate filters, catalyzed flow-through filters and diesel oxidation catalysts effectively reduce PM to levels of 25% to 85%, they also provide important co-benefit of reducing emissions of hazardous air pollutants (HAP), CO and VOCs. 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. Given the well-documented environmental and health benefits of reducing emissions of PM, CO, VOC and HAP, these multi-pollutant co-benefits are significant.

Available Emission Control Technologies for 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 (DPF), flow-through filters (FTF) and diesel oxidation catalysts (DOC).

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 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 regenerated intermittently. Both passive and active techniques can be used. Passive DPF systems regenerate using available exhaust heat and/or the oxidation of available engine-out NO to NO_2, a powerful oxidizing agent for trapped carbon, to combust the soot during regeneration. Active DPF systems are specifically designed for low exhaust temperature applications and employ additional energy inputs to facilitate regeneration, such as diesel fuel injection strategies, engine throttling strategies, the use of electrical heating elements, or fuel burners. 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.

In the rare number of stationary engine installations where the engine may have been oversized for the normal operating load, a load bank may need to be installed to achieve exhaust temperatures high enough for regeneration of the soot. The appropriate temperature may vary between DPF technologies but several manufacturers have experience with achieving sufficient regeneration temperature at 25% of maximum engine load and in some cases as low as 10% of full load. Although operating stationary engines at such low loads is not typical, nor recommended, DPF device manufacturers have developed catalyst formulations to accommodate low exhaust temperatures. The best technical solution for any application should be assessed on a case by case basis to properly size the device for the operating load and exhaust temperatures.

Diesel oxidation catalysts (DOCs) are another important and inexpensive 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 have achieved total particulate matter reductions of up to 25 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. Oxidation catalyst technology is a very cost effective emission reduction technology that has been extensively used on stationary lean-burn natural gas and lean-burn diesel engines to achieve significant reductions in HC, CO and PM emissions 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. Flow-through filters are capable of achieving PM reductions of about 50 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. One manufacturer has verified an actively regenerating Level 2 device ideal for low exhaust temperatures typical of low load applications.

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 have been 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. U.S. EPA verified CCV systems are typically installed in combination with either a DPF or a DOC and are a cost effective way to achieve additional PM reductions.

Feasibility of Emission Control Technologies for Existing Stationary Diesel Engines

MECA believes that exhaust emission controls are a commercially 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). 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. 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 July, 2011, there are ten 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.

ARB has 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. 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).

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. 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, as well as, to very large installations on emergency back-up or prime power generators with several megawatts of power. This experience base includes both passively and actively regenerated DPF systems. Another 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.

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

- 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.
- 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.

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.

Black Carbon Emissions from Existing Stationary Diesel Engines

Reducing diesel PM emissions from new and in-use stationary engines not only provides health-based benefits but also climate change co-benefits associated with black carbon reductions. Black carbon is a major component of PM emissions from fossil fuelburning 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 the commercially available PM emission control technologies discussed above. 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.

Conclusion

In closing, MECA fully supports the proposed amendments to Rule 1470. We commend the air district for taking an important step beyond the U.S. EPA's NSPS and the ARB's Stationary ATCM to reduce PM emissions from new emergency standby 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 standby stationary diesel engines.

DPFs, in particular, have demonstrated to be very effective in reducing PM emissions from both mobile and stationary diesel engines. The use of 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, VOCs and CO when catalyst-based DPFs are employed. In addition, the combination of DPFs with SCR systems can be an effective solution for delivering combined PM and NOx reductions from new and in-use stationary diesel engines. In situations where DPFs are not technologically feasible, FTFs and DOCs should be considered as an alternative option to help achieve some level of PM control from this category of engines. MECA and its member companies look forward to working with SCAQMD, the engine and equipment manufacturers, end-users, and others in implementing the changes proposed to Rule 1470.

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