Comments of the Manufacturers of Emission Controls Association on the U.S. Environmental Protection Agency's Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder Proposed Rulemaking

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The Manufacturers of Emission Controls Association (MECA) is pleased to provide comments in response to the U.S. EPA's Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder 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 believes an important opportunity exists to significantly reduce emissions from Category 3 marine diesel engines through the combination of continued improvements in engine designs, the application of appropriate exhaust emission controls, and the use of lower sulfur fuels. MECA agrees with EPA's assessment that the focus of the proposed standards should include a two-phase approach – mirroring the Tier 2 and Tier 3 emission standards that were added to the International Maritime Organization's (IMO) MARPOL Annex VI regulations – that would first achieve modest particulate matter (PM) and sulfur oxide (SOx) reductions through the use of lower sulfur fuels and/or exhaust gas cleaning technologies (as early as 2011) and then provide meaningful, long-term reductions in nitrogen oxide (NOx) emissions through the application of high-efficiency, catalyst-based emission controls (e.g., selective catalytic reduction technology) to these engines in the 2016 timeframe.

MECA is a non-profit association made up of the world's leading manufacturers of emission control technology for mobile source applications and stationary internal combustion engines. A number of our members have extensive experience in the development, manufacture, and commercial application of emission control technologies for new and in-use diesel engines, including diesel engines used in nonroad applications such as Category 3 marine diesel engines.

Introduction

MECA supports EPA's proposed Tier 2 NOx standards for Category 3 marine diesel engines and believes they are technically feasible using such approaches as common rail fuel injection, advanced turbochargers, and improved valve timing and combustion chamber design. Common rail systems are currently being produced by major manufacturers of Category 3 marine diesel engines. Use of this technology along with other approaches will allow manufacturers to meet the proposed Tier 2 NOx standards in the timeframe proposed by EPA.

MECA also supports the proposed Tier 3 NOx standards and believes they are achievable in the timeframe proposed by EPA. Today, over 300 Category 2 (marine

diesel engines less than 30 liters per cylinder) and Category 3 engines have been equipped with selective catalytic reduction (SCR) technology; some of these marine vessels have been in service for 10 years and have accumulated 80,000 hours in-use with the SCR aftertreatment systems in place. Furthermore, given the significant experience base with SCR installations on large marine vessels over the past fifteen years, MECA believes that the implementation of EPA's proposed Tier 3 NOx levels for new Category 3 marine diesel engines could be accelerated and could occur within three years following the implementation of proposed Tier 2 standards.

EPA has not proposed to set PM emission standards for Category 3 engines but would require engine manufacturers to measure and report PM emissions. Instead, PM (and SOx) emissions would be reduced through the use of lower sulfur marine diesel fuel (1,000 ppm sulfur fuel) that would be required if the U.S. and Canada receive IMO approval to designate their coastal waters as an Emission Control Area (ECA; this ECA petition has already been submitted to IMO). MECA supports this 1,000 ppm sulfur requirement, but urges EPA to take a leadership position of setting a timetable for further reductions in the fuel sulfur level. We also support the Agency's plans to evaluate the impacts of its proposed rulemaking on PM emissions, and to assess the feasibility of further PM reductions from ocean-going vessels and propose a PM standard if appropriate.

We encourage EPA to consider the establishment of a program to reduce PM and NOx emissions from existing Category 3 engines since these engines will be in service for many years to come and will continue to pollute at very high rates unless action is taken to reduce their emissions. We believe that a Voluntary Marine Verification Program, as described in the proposed rule, could play an important role in addressing emissions from existing engines. We urge EPA to pursue the development of such a program. PM and NOx emission control technology options have already been developed and demonstrated on existing large marine vessels, suggesting that a large-scale retrofit program could be technically feasible. The program could provide incentives for demonstrations of advanced technologies that provide emission reductions in advance of the effective dates of the proposed Tier 2 and Tier 3 standards or that provide emission reductions beyond the proposed standards.

SCR Technology for Marine Diesel Engines

MECA would like to focus the majority of its comments on the technical feasibility and experience base with SCR technology for large marine diesel engines. Our comments on marine SCR technology provide strong support for the potential of this technology to achieve high efficiency NOx reductions consistent with EPA's proposal for a Tier 3 marine diesel engine NOx emission standard. As indicated in EPA's NPRM, SCR catalyst technology is capable of significant NOx reductions from marine diesel engines even when these engines are operated on fuels with high sulfur levels (e.g., 15,000 to 35,000 ppm S).

SCR technology is a proven NOx control strategy. SCR has been used to control NOx emissions from stationary sources for over 20 years using either ammonia or urea injection ahead of the SCR catalyst to serve as the reductant that reacts with NOx in the lean diesel operating environment. Applying SCR to diesel-powered engines provides simultaneous reductions of NOx, PM, and HC emissions. Open loop SCR systems can reduce NOx emissions from 75 to 90%. Closed loop systems have achieved NOx reductions of greater than 95%.

The experience from stationary applications of SCR technology can be applied to marine diesel installations due to the similar, non-transient modal operating conditions employed in both applications. Stationary demonstrations range from diesel back-up generators, gensets, and stationary engines used on large construction cranes. MECA has summarized this experience of installing emission control technology on stationary diesel engines in a report entitled "Case Studies of Stationary Reciprocating Diesel Engine Retrofit Projects (August 2007)." The report is available at: www.meca.org/galleries/default-file/Stationary%20Engine%20Diesel%20Retrofit%20Case%20Studies%200807.pdf.

More recently, SCR systems have been applied to mobile sources, including trucks, off-road equipment, and marine vessels. Modern SCR system designs have been detailed for mobile source applications that combine highly controlled reductant injection hardware, flow mixing devices for effective distribution of the reductant across the available catalyst cross-section, durable SCR catalyst formulations, and ammonia slip clean-up catalysts that are capable of achieving and maintaining high NOx conversion efficiencies with extremely low levels of exhaust outlet ammonia concentrations over thousands of hours of operation.

Heavy- and medium-duty truck and engine manufacturers in North America are adopting SCR to meet EPA's 2010 heavy-duty highway emissions standards. Similarly, in Europe, the majority of heavy-duty engine manufacturers are offering SCR systems in highway truck applications to comply with Euro IV and V emission regulations, with more than 500,000 of these European SCR-equipped trucks already in service. SCR systems are also being used commercially in Japan for new diesel trucks by several engine manufacturers to comply with Japan's 2005 standards for new diesel trucks. Several technology providers are also developing and demonstrating retrofit SCR systems for both on-road trucks and off-road equipment that combine SCR catalysts with either DOCs or DPFs.

Since the mid-1990s, SCR technology using a urea-based reductant has been safely installed on a variety of Category 2 and Category 3 marine applications in Europe, including automobile ferries, cargo vessels, military ships, and tugboats, with over 300 systems installed on engines ranging from approximately 450 kW to over 10,000 kW. Many of these systems reduce NOx emissions from their vessels to under 1 g/kWh, with some applications operating at below 0.5 g/kWh NOx. The marine diesel SCR experience includes installation on both large two-stroke and four-stroke marine diesel engines. In most applications, vessels equipped with SCR systems have been

successfully operated on marine fuels with up to 1.5% sulfur levels (15,000 ppm). SCR systems on stationary engine applications have seem some limited operation on fuels with sulfur levels as high as 3.5% (35,000 ppm S).

Urea is the preferred reductant in these marine diesel installations, with urea consumption reported to be in the 4-5 gallons/hour/MW of engine power for a 40% urea in water solution. Nearly all of these marine SCR installations have employed vanadia/titania-based SCR catalyst formulations. In many cases, these marine diesel SCR installation have placed the SCR catalysts downstream of the engine's turbocharger, but there are also cases where the SCR catalysts have been installed upstream of the turbocharger to provide a better match between the exhaust temperature and the SCR catalyst operating window required to achieve a target NOx reduction.

In marine applications, SCR minimum operating temperatures are dictated by fuel sulfur levels and the temperatures that minimize the formation of sulfates on the catalyst surfaces. At relatively low fuel sulfur levels (1,000 ppm S), vanadia/titania-based SCR catalysts can operate as low as 260°C with minimal sulfate formation. At fuel sulfur levels of 10,000 ppm S, this same SCR catalyst formulation minimum operating temperature rises to around 320°C to minimize sulfate formation. To avoid plugging the SCR catalyst with carbon soot or other inorganic deposits, marine systems have also employed ultrasonic or pulse jet-based soot blowers. SCR catalyst life spans in marine applications can be 40,000 hours or even longer, depending on operating conditions and catalyst system design parameters. Vanadia/titania-based catalysts used in marine SCR applications are capable of extended operation at exhaust temperatures as high as 530°C before catalyst thermal degradation becomes an issue. As stated in EPA's NPRM, large marine diesel exhaust temperatures are typically maintained below 450°C to minimize engine exhaust valve impacts from corrosion or fouling from fuel-related impurities.

The Port Authority of New York and New Jersey conducted an innovative pilot project in 2006 to demonstrate diesel emission reduction technologies on a Staten Island ferry. The ferry was retrofitted with DOC+SCR systems on its two main, four-stroke propulsion engines. Emissions testing observed on the ferry showed NOx reductions that typically exceeded 94% during ferry cruise modes. In this project, the ferry engines were fueled with No. 2 diesel fuel with fuel sulfur levels in the 300-350 ppm range. Additional details on this Staten Island ferry project are available at: www.mjbradley.com/documents/Austen_Alice_Report_Final_31aug06.pdf.

The aforementioned U.S. ferry project, along with other operational, marine SCR installations on ocean-going vessels from outside the U.S., provides firm evidence that SCR systems can be engineered to meet rigorous marine industry conditions and safety standards. Some of these marine SCR systems have been operating since the 1990s with high NOx conversion efficiencies and no reported safety-related issues. Given the significant experience base with SCR installations on large marine vessels over the past fifteen years, MECA believes that the implementation of EPA's proposed Tier 3 NOx levels for new Category 3 marine diesel engines could be accelerated and could occur within three years following the implementation of proposed Tier 2 standards (e.g., in the 2014 timeframe assuming that Tier 2 standards are implemented as soon as 2011).

In addition to these written comments, MECA is also submitting a listing of SCR installations on large marine diesel applications that have been completed since 1995 by one MECA member company. This list includes more than 180 SCR systems installed on more than 50 vessels (propulsion and auxiliary engines). Also, MECA recently issued a report entitled "Case Studies of the Use of Exhaust Emission Controls on Locomotives and Large Marine Diesel Engines (September 2009)," which includes select case studies on the installation of NOx emission control technology on large marine diesel engines. The report is available here: www.meca.org/galleries/default-file/Loco%20Marine%20Case%20Studies%20update%200909.pdf.

PM Emission Control Technologies for Marine Diesel Engines

Technologies to reduce PM emissions from new and in-use marine diesel engines, such as diesel particulate filters (DPFs) and diesel oxidation catalysts (DOCs), are commercially available today. These catalyst-based emission control technologies have already been installed on millions of new light-duty and heavy-duty vehicles and equipment and as retrofit technology on hundreds of thousands of existing on-road and off-road diesel engines worldwide to provide significant reductions in PM emissions, as well as reductions in hydrocarbon (including toxic HCs, like poly-aromatic HCs) and carbon monoxide (CO) emissions.

The successful application of these catalyst-based PM reduction technologies, however, is dependent on the use of low or ultra-low sulfur diesel fuel since sulfur levels in the fuel can both deteriorate catalyst performance and contribute to PM emissions through the formation of sulfate emissions across the catalyst. This is why EPA's recent final rulemakings covering new highway, off-road, locomotive, and smaller marine diesel engines include or take advantage of the mandated use of ultra-low sulfur diesel fuel (15 ppm S max.) to facilitate the use of sulfur-sensitive, catalyst-based emission control technologies like DPFs and DOCs, as well as NOx adsorber catalysts. Similarly, for large ocean-going vessels, the application of catalyst-based DPFs and DOCs for PM reductions would not be practical until fuel sulfur levels are reduced to 500 ppm S, or in some cases even 50 ppm S, or lower. In this NPRM, EPA has only proposed reducing fuel sulfur levels to a minimum of 1,000 ppm for these large marine diesel engines. MECA supports this 1,000 ppm sulfur requirement, but urges EPA to take a leadership position of setting a timetable for further reductions in fuel sulfur to the ULSD level. This would extend catalyst durability (including SCR catalyst durability) and enable the use of DOC and DPF technologies for the reduction of PM.

Conclusion

MECA supports EPA's proposed rulemaking for Category 3 marine diesel engines. The proposal provides important PM and NOx reductions from ocean-going vessels in the near-term through improvements in engine technology and the use of lower sulfur fuels, and significant long-term NOx reductions through the use of proven SCR technology for large marine diesel engines. Continued development of SCR systems by

emission control technology suppliers for use on new highway, off-road, and stationary diesel engines and vehicles in the U.S., Europe, and Japan will provide a platform for future improvements in the performance, reliability, and cost of these systems in large marine diesel engine applications. Our industry has a strong commitment to SCR technology for mobile source applications and stands ready to work with engine manufacturers on large marine diesel engine applications.

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