STATEMENT OF THE
MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION
ON THE CALIFORNIA AIR RESOURCES BOARD'S PROPOSED REGULATIONS ON OPTIONAL LOW NOx EMISSSION STANDARDS

December 10, 2013

The Manufacturers of Emission Controls Association (MECA) is pleased to provide comments in support of the California Air Resources Board's proposed regulation to establish optional low NOx emission standards for heavy-duty engines.

MECA is a non-profit association of the world's leading manufacturers of emission control technology for mobile sources. Our members have over 40 years of experience and a proven track record in developing and manufacturing emission control technology for a wide variety of on-road and off-road vehicles and equipment, including extensive experience in developing emission controls for gasoline and diesel vehicles in all world markets. Our industry has played an important role in the emissions success story associated with mobile sources in the United States, and has continually supported efforts to develop innovative, technology-forcing, emissions programs to deal with air quality problems.

MECA supports ARB's proposed optional low NOx emission standards for heavy-duty engines. This proposal would establish optional exhaust emission standards for NOx that are more stringent than current federal and California standards to further reduce emissions from a significant emissions source. MECA agrees with ARB that this proposal would incentivize manufacturers to develop engines with lower NOx emissions and help California meet its obligations to improve ambient air quality and meet its State Implementation Plan commitments. The proposed standards would also accelerate the introduction of new advanced technologies that reduce NOx emissions into the market place.

MECA believes that the proposed optional low NOx emission standards for heavy-duty engines are technically feasible. As stated in ARB's staff report, technologies currently exist that could be expanded to enable manufacturers to meet the optional emission levels. Examples of advanced technologies that are available for further reductions of NOx emissions from heavy-duty, highway engines include advanced SCR catalyst systems for diesel engines (or other lean combustion engines), passive NOx adsorber catalysts for diesel engines (or other lean combustion engines), and advanced three-way catalyst systems for stoichiometric, natural gas engines.

Selective catalytic reduction (SCR) catalyst systems can significantly reduce NOx emissions from diesel engines (or other lean combustion engines fueled with alternative fuels such as natural gas). SCR is the technology of choice for reducing NOx emissions from today's U.S. 2010-compliant heavy-duty, highway diesel engines from the recently launched Euro VI-compliant heavy-duty, highway diesel engines in Europe, and from heavy-duty highway engines available in Japan that are compliant with Japan's 2009-2010 heavy-duty engine emission standards. In current applications these SCR systems are delivering in excess of 90% reduction of NOx on heavy-duty diesel engines. The SCR system uses a chemical reductant, usually a urea/water solution, to convert nitrogen oxides to molecular nitrogen in oxygen-rich exhaust

streams like those encountered with diesel engines. More recently other forms of reductants have been investigated including mixtures of ethanol and gasoline (most notably E85, 85% ethanol/15% gasoline), and solid ammonia precursors (e.g., ammonium carbamate, or metal chloride amines). Upon thermal hydrolysis in the exhaust, urea decomposes to carbon dioxide, steam, and ammonia which serves as the reductant. As exhaust and reductant pass over the SCR catalyst, chemical reactions occur that reduce NOx emissions to nitrogen and water.

In addition to NOx emission reductions, SCR applications on heavy-duty engines allows engine manufacturers to further optimize and reduce fuel consumption of these engines, providing important reductions in greenhouse gas emissions. Engine manufacturers that employ SCR technologies on 2010-compliant heavy-duty, highway engines in the U.S. and Canada claim up to 5% improvements in fuel efficiency vs. engines that do not employ SCR technology. These fuel efficiency improvements are most evident at highway speeds. The high NOx conversion efficiencies associated with SCR catalyst systems enable engines to be operated at conditions that yield lower fuel consumption. Engine manufacturers are expected to continue to further optimize engine fuel consumption characteristics and SCR system designs to provide additional benefits to fuel consumption and NOx emission reduction.

The recently released Advanced Collaborative Emissions Study (ACES) Phase 2 results (available from the Coordinating Research Council at www.crcao.org) have characterized the regulated and unregulated emissions from three 2010-compliant heavy-duty, highway diesel engines. These results document impressive, low emissions for these current technology diesel engines that all employ SCR technology. The NOx emissions from two of three engines tested in the ACES Phase 2 study exhibited de-greened NOx emission levels of 0.05-0.07 g/bhp-hr using the EPA-specified, heavy-duty transient test cycle, significantly below the 2010 NOx emission standard of 0.20 g/bhp-hr NOx. In fact the hot transient cycle NOx emission levels for these same two ACES diesel engines is at 0.02 g/bhp-hr or less, indicating that the majority of the NOx emissions from these engines are produced during the cold transient portion of the test cycle. These results suggest that heavy-duty diesel engines could achieve the staff proposed 0.10 g/bhp-hr voluntary NOx emission limit with some rather modest improvements in SCR system cold transient performance that could be provided by cost-effective improvements in the exhaust system heat management strategies employed on these diesel engines.

Further reductions in NOx emissions from heavy-duty diesel engines could be provided by using advanced SCR system technologies that have been developed recently by the emissions control industry including technologies such as SCR catalysts coated directly on diesel particulate filter (DPF) substrates, SCR catalysts with improved low temperature performance, passive lean NOx adsorbers (catalysts that adsorb NOx at exhaust temperatures below 200^{o}C and then release NOx as exhaust temperatures rise), and the use of alternative SCR reductant strategies. These advanced emission control technologies can all provide improved cold transient cycle NOx performance on a heavy-duty diesel engine. Cummins employed many of these lower temperature NOx emission control strategies in a recent Department of Energy-sponsored program that targeted SULEV emissions on a full size, light-duty, diesel-powered Nissan Titan pick-up truck. In their "ATLAS" test program (reported by Cummins at the 2012 DOE DEER Conference; presentation slides available at: http://www1.eere.energy.gov/vehiclesandfuels/resources/proceedings/2012_deer_presentations.html), a passive NOx adsorber was combined with an SCR-coated DPF, a direct ammonia reductant injection system, and additional advanced SCR catalysts in the exhaust of a four

cylinder diesel engine and shown to have the capability to achieve SULEV emission levels. This ultra-low NOx system approach also required appropriate cold-start engine control strategies to maximize the cold-start NOx performance of this advanced diesel exhaust emission control system.

An example of future improvements in SCR catalyst system designs is the direct application of SCR catalysts to diesel particulate filter substrates to provide a single catalyst module that provides reductions to all four criteria pollutants: hydrocarbons, CO, NOx, and PM. These SCR coated filters will lead to less complex emission system designs, reduced engine backpressure, and the ability to utilize the SCR catalyst more quickly after engine-start since the SCR catalyst function will be displayed directly on the filter which is most typically the first converter body present in a heavy-duty, highway engine application. VW has already announced that they will employ SCR-coated DPFs on future light-duty diesel engines for both European and U.S. applications.

MECA also agrees with ARB staff that advances and expanded use of other advanced technologies such as cooled EGR, EGR by-pass valve, and low and high pressure EGR could be used to effectively reduce NOx emissions to allow manufacturers to achieve the proposed optional NOx levels from future heavy-duty diesel engines.

In the case of stoichiometric, heavy-duty natural gas engines, these engines employ three-way catalysts to control NOx, like stoichiometric gasoline light-duty vehicles. These stoichiometric natural gas engines can make use of more advanced three-way catalysts and three-way catalyst system designs to achieve NOx emission levels consistent with the proposed voluntary low NOx emission standards. SULEV and PZEV-compliant stoichiometric gasoline vehicles employ strategies with much higher levels of NOx performance than today's stoichiometric, heavy-duty natural gas engines. Advanced three-way catalysts combined with higher cell density, low thermal mass substrates in configurations with close-coupled and underfloor converters that utilize improved cold transient calibrations are strategies that can be employed on future stoichiometric, natural gas engines to achieve the proposed voluntary, low emission NOx levels. At least one manufacturer of stoichiometric, heavy-duty natural gas engines has publicly stated that they intend to commercialize a 0.05 g/bhp-hr NOx-compliant engine in the 2015 timeframe.

MECA is partnering with ARB on an important heavy-duty engine technology test program that is targeting 0.02 g/bhp-hr NOx emission levels on both a diesel and stoichiometric natural gas engine. This program is just underway and is being run at Southwest Research Institute in San Antonio, TX. Many of the advanced diesel and stoichiometric natural gas NOx emission control technologies mentioned above will be evaluated in this test program over the coming three years.

In conclusion, MECA supports ARB's proposed voluntary low NOx emission standards for heavy-duty vehicles. MECA believes that this proposal would incentivize manufacturers to develop engines with lower NOx emissions and help California meet its obligations to improve ambient air quality and meet its State Implementation Plan commitments. MECA also believes that the proposed optional standards would accelerate the introduction of new advanced technologies that reduce NOx emissions into the market place.

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