WRITTEN STATEMENT
OF THE
MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION
ON THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S PROPOSAL TO REVISE THE NATIONAL AMBIENT AIR QUALITY STANDARDS FOR OZONE
DOCKET ID NO. EPA-HQ-OAR-2008-0699

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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 Ozone (Docket ID No. EPA-HQ-OAR-2008-0699). MECA firmly believes that the emission control technologies for mobile sources that will be needed to help meet the most stringent standards for ozone are cost effective and readily available. Many of these 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 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 non-road vehicles and equipment. A number of our members have extensive experience in the development, manufacture, and application of hydrocarbon, PM and NOx emission control technologies for both new and existing engines. These companies have commercialized control technologies for gasoline, diesel, and alternative-fueled engines.

MECA will defer to the health experts to determine the appropriate ozone 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.

While beyond the scope of the health-based decision before the agency, MECA offers comments here to demonstrate there are technologically feasible and cost effective emission control technologies for mobile source engines that are available to meet the most stringent ozone standards under consideration by EPA. MECA commends EPA for proposing to update the ozone standards to ensure that the standards are as protective as recommended by EPA's Clean Air Scientific Advisory Committee (CASAC).

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 2007-2010 heavy-duty highway engine emission program, followed by the Tier 4 non-road diesel emission regulations that have been phased in over the 2008-2015 timeframe. Both of these regulatory programs rely on a systems approach that combines advanced diesel engine technology, the use of ultra-low sulfur diesel fuel, and advanced diesel exhaust emission control technologies to achieve significant reductions in both PM and NOx emissions compared to older technology diesel engines.

Diesel exhaust emission control technologies, that will play a major role in complying with EPA's emission standards for new diesel engines, include diesel oxidation catalysts (DOCs), diesel particulate filters (DPFs), closed crankcase filters (CCFs), selective catalytic reduction catalysts (SCR), and NOx adsorber catalysts. High efficiency diesel particulate filters are already standard equipment on all new light-duty diesel vehicles and on-road heavy-duty diesel trucks sold in the U.S. and Canada. These filters provide more than 95% reduction in particulate mass over a very broad range of particle sizes and have proven durability over hundreds of thousands of miles of service. Similar diesel particulate filter systems are being used by some manufacturers to comply with EPA's Tier IV final emission standards for nonroad engines. The significant reductions in diesel particulate emissions that result from the use of filters not only provides significant health-related benefits but also significant climate change impacts due to the large reduction in black carbon emissions associated with filter operation on diesel engines. Particulate filter technology could also be used in the future as a strategy to reduce the mass and number of particulate emissions from direct injection gasoline vehicles to ensure that these future powertrain technologies' PM emissions are equivalent to those associated with filtered diesel exhaust.

The emergence of "clean diesel" light-duty vehicles in the U.S. that employ DPFs, SCR catalysts, and/or NOx adsorber catalysts, and the significant number of ultra-low tailpipe and evaporative emission light-duty gasoline vehicle models that have been certified to California's partial-zero emission vehicle (PZEV) or super ultra-low emission vehicle (SULEV) standards provides strong evidence that new light-duty vehicles sold in the U.S. are capable of achieving hydrocarbon and NOx exhaust emissions to comply with a more stringent ozone standard. California's LEV III and EPA's Tier 3 light-duty vehicle programs will deploy proven advanced emission control technologies for both exhaust and evaporative emissions to achieve further reductions in hydrocarbon and NOx emissions in new passenger cars and light-duty trucks. These LEV III/Tier 3 regulations also require gasoline light-duty vehicles to meet tougher evaporative emission requirements. Technologies including advanced carbon canister designs, the use of advanced materials with ultra-low fuel permeation characteristics for fuel tanks and fuel lines, and air intake hydrocarbon adsorbers are available today to meet the stringent evaporative emission requirements required by these light-duty regulations. NOx adsorber technology is another available NOx control strategy that can reduce NOx emissions from light-duty diesel and lean gasoline engines. NOx adsorber catalysts have been used commercially in some light-duty gasoline direct injection (GDI) engines sold in Europe and Japan and on several light-duty and medium-duty diesel vehicles in the U.S. to comply with either the ARB LEV II/EPA Tier 2 light-duty vehicle emission limits or EPA 2010 heavy-duty engine emission standards. Manufacturers are demonstrating novel application of NOx adsorber technologies on lean-burn GDI engines in combination with a downstream SCR. In such applications, the primary role of the NOx adsorber is to generate the ammonia reductant during periodic rich operation that is stored on the downstream SCR catalyst and consumed to reduce NOx during lean operation. A similar approach utilizes a three-way catalyst to generate ammonia during rich operations that can be stored on an underfloor SCR catalyst for NOx control under lean engine operations. These approaches may be used by vehicle manufacturers to meet future LEV III/Tier 3 regulations on future lean GDI engines that offer attractive improvements in fuel consumption for achieving future EPA light-duty vehicle greenhouse gas standards. The types of technologies being developed for light-duty passenger cars to meet these future ultra-low emission levels from passenger cars will find their way to applications on medium and heavy-duty on-road vehicles and engines and ultimately the nonroad sector as well to achieve NOx levels below those required by today's Tier 4 final standards.

In their Regulatory Impact Analysis (RIA, Table 3-1), EPA reported 2025 baseline NOx emissions of 9,530 ktons, including 1,492 ktons from on-road and 796 ktons from nonroad heavy-duty vehicles and equipment. Although the California NOx inventory was not included in the RIA, the Northeast and Mid-Atlantic states represented by the Ozone Transport Commission (OTC) share many of the ozone concerns with California. In addition to ozone transported from the west, the Northeast and Mid-Atlantic states are impacted by significant NOx emissions from mobile sources along the I-95 corridor. Approximately 46% of the NOx emissions in this region are attributed to mobile sources with 60% of these coming from on-road sources. Table 4-10 of the RIA summarizes the emission reductions from known and unknown controls for regions in the eastern and western United States impacted by the 60, 65, and 70 ppb alternate standards. By far, the majority of these reductions occur in the eastern half of the United States. The unknown NOx reductions in the east represent 150, 750 and 1,900 ktons respectively for the 70, 65 and 60 ppb alternative standards. In the RIA baseline and alternate standard analyses, EPA applied only a single known mobile control measure, nonroad diesel retrofits and engine rebuilds, to reduce NOx by 5 ktons at a cost of $4,600/ton. The remaining known NOx controls were derived from stationary sources such as electricity generating units (EGUs), non-EGU point and nonpoint sources at an average cost of $12,000/ton, $3,000/ton and $1,100/ ton, respectively. The weighted cost of these stationary controls necessary to achieve the 65 ppb alternative standard is $3,732/ton of NOx. We believe that the majority of the unknown NOx reductions can be achieved cost effectively from mobile sources if the types of NOx reduction measures under discussion in California were to be adopted across the remaining 49 states by EPA.

MECA believes that further reductions in NOx emissions from new heavy-duty on-road and off-road diesel engines beyond the 2010 on-road and Tier 4 off-road requirements will be possible through the combinations of more advanced diesel engines with advanced diesel exhaust emission control technologies including advanced substrates, improved SCR catalysts and/or NOx adsorber catalysts. The California Air Resources Board (ARB), recognizing these opportunities, adopted voluntary on-road low NOx standards and incentives to encourage manufacturers to develop state-of-the-art engines and emission controls to achieve NOx levels as low as 0.02 g/bhp-hr which is equivalent to a 90% reduction from EPA's 2010 highway, heavy-duty engine standards. Additional tightening of NOx standards for both heavy-duty on-road and off-road new diesel engines beyond the 2010 on-road requirements and the Tier 4 final off-road requirements should be considered by EPA as a cost effective strategy that would further reduce ozone levels across the country.

To demonstrate the feasibility of achieving these low NOx levels from heavy-duty engines, ARB and MECA are funding a test program at Southwest Research Institute on a state-of-the-art 13 L Euro VI certified engine as well as a 12 L stoichiometric natural gas engine. The program focuses on reducing NOx emissions from the low temperature portions of the test cycle including cold-start and low speed operation. MECA is providing several exhaust system solutions for both engines that will deploy the most advanced substrate and catalyst combinations into novel system architectures focused on low temperature NOx reduction.

Beyond catalyst advances, the next generation NOx reduction strategies will require careful attention to both active and passive thermal management strategies to retain the exhaust heat provided by the engine for activating catalytic controls, as well as, offering innovative approaches to actively heat the exhaust during low speed and low load operation of the engine when exhaust temperature is at a premium. An example of the types of thermal management strategies being considered under this program include dual wall and insulated exhaust pipes, dual wall stamped exhaust manifolds, active exhaust heating systems and thermally insulating substrate mounting materials along with other low thermal mass exhaust components. To achieve these very low NOx levels will require advanced reductant delivery systems and close attention to reductant dosing control strategies. To complete the system approach, SwRI engineers will optimize the engine calibration strategies to deliver the lowest possible engine-out emission levels in the exhaust. The goal of the program is to demonstrate the capabilities of next generation advanced NOx reduction technologies with no impact on the fuel efficiency of the diesel and natural gas engines. MECA is extremely confident that its members will deliver a successful result. ARB anticipates releasing preliminary results in early 2016 with final results later on in 2016.

To estimate the achievable level of NOx inventory reduction through the deployment of technologies being demonstrated by the low NOx test program, MECA funded an independent emission inventory forecast study, at ENVIRON, to better understand the full benefit of future potential NOx tightening for both on-road and nonroad heavy-duty diesel engines. This analysis relied on EPA's current official models, including MOVES2014 for on-road vehicle emissions and the NONROAD2008 (within the National Mobile Inventory Model, or NMIM, framework) model for off-road emissions. These models account for all "on-the-books" regulations, including the recently finalized Tier 3 light-duty vehicle requirement, and are consistent, but not exactly the same, with the Base Case (i.e. with current emission controls) used in EPA's ozone NAAQS proposal. In the RIA, EPA used a modified version of the MOVES2010 that was adjusted to include Tier 3 (MOVESTier3FRM). Because of slight differences in the model input parameters between the EPA version of MOVES, used in the RIA, and MOVES2014 used in this study, the results were put on the same basis by multiplying the ratio of the models' forecasted emission totals for each calendar year by the 2025 Base EPA RIA inventory estimates. To estimate the future NOx reduction potential of new controls, by-model-year emissions were determined for on-road vehicles, and modified input databases for the NONROAD model for the off-road equipment to develop emissions estimates with and without new potential future emissions standards. The models were run to generate emissions inventories of NOx, VOC, CO and PM for on-road and off-road sources for calendar years 2025, 2030, 2040, and 2050 for the Base Case and the control scenarios discussed below.

For the heavy-duty sector controls scenarios, we selected NOx reduction and implementation timeline inputs for these sectors based on California ARB's June 28, 2012 Vision Document. The model inputs included a 90% NOx reduction from heavy-duty diesel, on-road engines below 2010 levels phased-in over the 2021-2024 timeframe. For the heavy-duty nonroad fleet, we assumed a nominal 70% NOx reduction from Tier 4 final levels for engine power ranges from 75-750 hp and an 80% NOx reduction from the small diesel nonroad power category from 25-75 hp. The NOx reductions from the nonroad engines were phased in from 2025-2027 and staggered by power ranges analogous to those used to phase-in Tier 4 final nonroad engine standards. To be consistent with EPA's ozone NAAQS Regulatory Impact

Analysis, we selected a 2012 baseline emissions inventory using the MOVES2014 and NONROAD2008 models and projected regional benefits consistent with the ozone impacted regions used in the RIA for the 70, 65 and 60 ppb alternate ozone standard scenarios. Because the regions impacted by a potential 60 and 65 ppb standard are similar, we combined these into a single scenario (65/60 ppb).

Because of the implementation timing that these heavy-duty highway and nonroad engine regulations could take affect extends beyond the 2025 model year used in the RIA, their impact on reducing NOx emission in the near term is limited. Our modeling work estimates that the on-road, heavy-duty diesel sector could deliver 14.4 ktons and 35.8 ktons of NOx reduction under the 70 ppb and 65/60 ppb alternative standards within the impacted regions in 2025. Similarly, the nonroad sector could achieve 3.8 ktons and 7.4 ktons of NOx reduction for the two study regions in that year because of the implementation timeline selected in this study. Because ozone will continue to pose health impacts far beyond 2025 we estimated the NOx reduction potential of the fully implemented and phased-in regulations out to 2050. The reductions from the on-road sector are estimated to be 74.9 and 190.8 ktons for the 70 and 65/60 ppb alternate standards, whereas the non-road sector could achieve 72.6 and 145.4 ktons respectively, for the impacted regions in 2050. When fully implemented under the 65 ppb alternate standard scenario, these two heavy-duty mobile control measures deliver over 335 ktons/year of NOx reductions and are in the range of the single largest stationary NOx control measure listed in the RIA (Table 4A-9). The NOx emission benefit of potential federal heavy-duty standards will extend beyond the county regions analyzed in the RIA as the operation of these vehicles will not be limited to nonattainment areas. We therefore extended our analysis to the 47 contiguous states including the District of Columbia but excluding California. The modeling results show that these two heavy-duty mobile control measures have the potential of delivering over 481 ktons/year of NOx reductions across the 47 lower United States plus D.C. We believe that these two heavy-duty control measures combined represent the largest opportunity for achieving NOx reductions from the mobile sector.

To derive a cost effectiveness value, we estimated the incremental cost of the types of additional emission controls, discussed above, that would be necessary to achieve the target reductions from heavy-duty trucks, beyond the exhaust controls being used to meet current 2010 heavy-duty on-road standards and from nonroad equipment relative to Tier 4 final standards for the 25-750 hp power ranges. The next generation of exhaust reductions can be achieved through incremental improvements to the major emission control devices that are already on vehicles and equipment to meet today's standards. Our incremental cost estimate for future advanced on-road emission control systems is approximately $500 per vehicle averaged over the medium and heavy-duty highway fleet. For nonroad equipment, the incremental cost varies more widely due to the broad power range and equipment configurations that make up this sector. An average incremental cost of exhaust controls, beyond Tier 4 final, over the 25-750 hp power range is approximately $350 per engine.

Based on the results of our analysis, we estimate that on-road trucks can deliver NOx reductions at a cost of $3,000-$4,000 per ton. Because there are greater opportunities to reduce NOx from the nonroad sector, we estimate that these reductions can be achieved within a range of costs from $1,000 - $1,500 per ton of NOx. Both of these control measures are well below

EPA's threshold of $15,000 per ton used for consideration in the RIA. The NOx weighted average cost benefit of these potential heavy-duty regulations combined is approximately $2,500/ton which is 33% lower than the NOx weighted cost of $3,700/ton estimated for the stationary cost of controls discussed in the ozone RIA.

Our assumptions for the types of controls that will be used to reduce NOx from mobile sources in the calculations above is based on continued use of Selective Catalytic Reduction (SCR) technology. We believe that SCR catalysts will continue to be the predominant NOx reduction strategy deployed on next generation heavy-duty trucks and nonroad equipment. The use of SCR to reduce NOx has a long history. SCR has been used to control NOx emissions from stationary sources for over 20 years. More recently, it has been applied to select mobile sources including trucks, marine vessels, and locomotives. In 2005, SCR using a urea-based reductant was introduced on a large number of on-road diesel heavy-duty engines to help meet the Euro V heavy-duty NOx emission standards. Hundreds of thousands of new heavy-duty truck engines are operating in Europe equipped with SCR systems that use urea as the reductant for reducing NOx emissions. SCR is being used by most engine manufacturers for complying with on-road heavy-duty diesel engine emission standards in both the U.S. for 2010 compliance, and Japan for 2009 compliance. In addition to delivering reductions in criteria pollutants, application of SCR on heavy-duty trucks allows engine manufacturers to further optimize and reduce fuel consumption of these engines, providing important reductions in greenhouse gas emissions. Achieving improvements in low temperature NOx reduction through thermal management strategies, passive NOx adsorbers and improved low temperature catalyst activity will provide engine manufacturers a broader operating window for optimizing their engine calibration for fuel efficiency while taking advantage of advanced low temperature catalysts to remediate any increases in NOx resulting from the calibration change.

Specifically to address NOx emitted at low exhaust temperatures, manufacturers are developing passive NOx adsorber (PNA) catalyst technology which is used upstream in combination with the DOC to trap and store NOx at temperatures below 200^{o}C before the SCR catalyst becomes active. Once the exhaust temperature is sufficient for SCR catalyst activity and to allow the urea dosing system to be activated, the NOx stored on the PNA begins to desorb and can be converted by the ammonia reductant over the SCR catalyst. This new technology will likely be one of the strategies available to engine and vehicle manufacturers to achieve lower tailpipe NOx levels.

Since the mid-1990s, SCR technology using a urea-based reductant has been installed on a variety of marine applications in Europe including ferries, cargo vessels, and tugboats with over 200 systems installed on engines ranging from approximately 450 to over 10,000 kW. These marine SCR applications include the design and integration of systems on a vessel's main propulsion and auxiliary engines. SCR systems have been successfully installed on one of New York City's Staten Island ferries and ferries operating in the San Francisco area. A smaller number of SCR systems have been installed on diesel locomotives in Europe and the U.S. to validate the performance of SCR catalysts in another off-road application area. EPA cited SCR catalysts as the most feasible technical approach for complying with its Tier 4 locomotive and commercial marine diesel engine emission standards that began in 2014. SCR technology is being applied on some ocean-going vessels to reduce NOx emissions consistent with the

International Maritime Organization's Tier 3 NOx requirements that will be required in designated Emission Control Areas near many coastlines around the world (including the ECA designations for the coastlines of the U.S. and Canada).

Similarly, MECA believes that further reductions of hydrocarbon and NOx emissions from the in-use fleet of passenger vehicles can be achieved cost effectively by adopting tighter aftermarket converter requirements for light-duty, gasoline vehicles that set higher performance and durability standards consistent with performance standards required by California for aftermarket gasoline converters since 2009. ARB's regulation eliminates the sale of older aftermarket converter products that have modest performance standards and a limited 25,000 mile warranty, and require that higher performance and more durable OBD-compliant aftermarket converter products be used on both non-OBD and OBD-equipped vehicles since January 2009. New York adopted California's aftermarket converter requirements in January 2014. These ARB-approved OBD-compliant aftermarket converters are warranted for five years or 50,000 miles based on the use of a more aggressive, high temperature accelerated engine-aging protocol compared to the vehicle durability demonstration currently required by EPA for approved aftermarket converter products. EPA has not updated its aftermarket converter requirements since 1986 and with more than three million aftermarket converters sold per year across the U.S. (based on surveys completed by MECA with aftermarket converter manufacturers), significant additional reductions of hydrocarbon emissions, including toxic hydrocarbon emissions, and NOx emissions could be achieved with a national aftermarket converter policy that made use of the same higher performance OBD-compliant aftermarket converters available in California and New York. For example, ARB estimated that requiring these advanced aftermarket converters in California would result in the reduction of over 36 tons/day of HC + NOx, at a cost effectiveness of $3,760/ton in 2012, once the new technology was fully implemented. Similarly, the Ozone Transport Commission estimated a reduction of 12,000 tons/year of NOx and HC (36 tpd) from the in-use light-duty fleet in the Northeast and Mid-Atlantic states through adoption of stricter aftermarket converter standards under a revised federal program.

A recent test program conducted and published by MECA (SAE technical paper 2013-01-1298) compared the tailpipe emissions of 6 passenger cars and light-duty trucks certified to LEV I emission standards. The vehicles were equipped with fully aged federal and California aftermarket technology converters and tested over the FTP-75 emission test cycle. After 25,000 miles of equivalent aging, the California converter technology emitted 85% less NOx and 65% fewer hydrocarbons and carbon monoxide than the EPA converter. MECA contracted with ENVIRON to run the MOVES2014 model and calculate the emission inventory reduction in tons per year of ozone precursors as a result of just upgrading the federal requirements to match the California 2009 standards. We believe this change could be fully implemented before 2025 because the technology is available and already being sold in California since 2009 and New York State since 2014. Based on state inspection and maintenance program statistics and MECA's annual aftermarket converter sales surveys, approximately 1% of light-duty vehicles experience an OBD catalyst error code, or fail their IM-240 emissions test, as a result of a damaged converter. We assumed a 2018 implementation date in our modeling work and a five year life for an aftermarket converter based on the duration of a California warranty. It was assumed that after 5 years the aftermarket converter would be replaced with another aftermarket converter resulting in full implementation of the advanced technology after five years. The maximum reduction benefit would be achieved over 5% of the total light-duty car and truck fleet. The MOVES2014 model predicts that 8,800 tons/year of NOx + HC would be reduced for the 70 ppb alternate standard and 20,600 tons/year for the 65/60 ppb alternate standard in 2025. Extended to the 47 contiguous states plus D.C. the reduction potential grows to 31,500 tons/year of ozone precursors. These NOx and HC reductions can be achieved by an average incremental cost of only $150 above the cost of today's federal aftermarket converter.

In reality the NOx emissions impact could be much worse now that most states are relying on OBD-based inspection and maintenance programs. When a typical EPA certified Tier 2 Bin 5 vehicle triggers an engine light (MIL) it could be emitting only slightly above its certified emission limit. By replacing the deteriorated OEM converter with a brand new EPA aftermarket converter, that is required to achieve only a 30% reduction in NOx, the vehicle may end up emitting far more NOx, as much as 14 times more, than it was emitting before the deteriorated OE converter was just replaced. On the other hand, a new California aftermarket converter must match the emission limit that the vehicle met when new and is equivalent to the OEM converter.

Another strategy that can achieve additional NOx emission reduction to meet the most stringent ozone standards would be for EPA to adopt California's 0.6 g/bhp-hr HC + NOx, 2010 emission standard for off-road spark-ignited engines with power ratings greater than 25 horsepower. The technology to reduce emissions from these SI engines is based on automotive-type closed-loop, three-way catalyst technology. This technology has been used on well over 300,000,000 automobiles with outstanding results. These same catalyst technologies have been adapted to spark-ignited engines used in off-road mobile sources such as forklift trucks, airport ground support equipment, and portable generators. Closed-loop, three-way catalyst-based systems are already being used on these large, spark-ignited, off-road engines to meet ARB's and EPA's 2004 3.0 g/bhp-hr HC + NOx standard. Closed-loop, three-way catalyst systems are also the primary technology pathway for meeting the EPA and ARB 2007 exhaust emission standard of 2.0 g/bhp-hr HC + NOx. Retrofit kits that include air/fuel control systems along with three-way catalysts have been sold into the LPG-fueled fork lift industry for installation on uncontrolled engines (an LSI application) for nearly 10 years. In both new engine and retrofit applications, these closed-loop three-way catalyst systems have shown durable performance in LSI applications, consistent with the excellent durability record of closed-loop three-way catalyst systems used in automotive applications for more than thirty-five years. MECA believes that advanced three-way catalyst technology based on automotive applications can provide a cost-effective, durable, high performance solution for controlling NOx and HC emissions from new and existing large spark-ignited engines used in stationary applications.

In July 2006, EPA finalized its regulation for new stationary compression ignition internal combustion engines to reduce diesel air pollution emissions. In February 2010, EPA issued its final regulation for existing stationary reciprocating internal combustion engines that would reduce toxic pollution emissions. The technologies discussed in this document for gasoline and diesel engines on vehicles are available and have been proven effective for stationary internal combustion engines. These include DOCs and SCR catalysts as well as DPFs to reduce PM emissions from stationary diesel engines. Three-way catalysts, also known as nonselective catalytic reduction catalysts (NSCR), have been used effectively on thousands of large, natural gas-fueled, reciprocating engines (so-called rich burn or stoichiometric natural gas engines) used for power production or pumping applications. Additional tightening of standards for both existing and new stationary internal combustion engines should be considered in the future to further reduce the HC, NOx and PM emissions that contribute to ozone levels across the country from these stationary engines.

MECA believes that additional NOx emissions reduction can be achieved by adopting more stringent HC + NOx emission standards for Class II off-road, spark-ignited engines with horsepower ratings less than 25 horsepower. Further reductions of HC + NOx emissions than what is required by the current Phase III EPA standards for these nonroad gasoline engines is technologically feasible through the use of catalyst technology that is fully optimized as part of a complete engine/emission control/exhaust system. Small engine manufacturers have been able to meet these standards through the redesign of existing Class II engines or through the use of emission credits, without the application of three-way catalysts. Both EPA and ARB have shown that the application of catalysts to nonroad equipment with Class II spark-ignited engines can be accomplished using available engineering exhaust system design principles in a manner that does not increase the safety risk relative to today's uncontrolled equipment. In particular, the EPA safety study on non-handheld equipment outfitted with catalyzed mufflers represents the most thorough safety study completed to date on this class of spark-ignited engines. The results of this EPA study showed that properly designed catalyzed mufflers pose no incremental increase in safety risk (and in many cases even lower muffler surface temperatures) relative to currently available non-handheld equipment sold without catalysts. An opportunity for further reductions in Class II HC + NOx emissions through the application of three-way catalysts should be considered by EPA as a way to achieve reductions of ozone precursors from this sector of engines. Furthermore, small engines pose significant health exposure hazards to end users due to the close proximity to the exhaust during normal operation. These health exposures to toxics and criteria pollutants should be considered as part of future justification to further tighten emission standards for small spark-ignited engines.

Other off-road spark-ignited engines including those used on ATVs, off-road motorcycles, outboard marine engines, and snowmobiles are contributors to mobile-source hydrocarbon and NOx emissions. MECA believes that hydrocarbon and NOx emissions from these recreational engines can be significantly reduced by adopting tighter regulations that employ the use of advanced three-way catalysts for these mobile sources. All classes of off-road, spark-ignited engines can also benefit from advanced materials and systems developed for controlling evaporative emissions from PZEV or SULEV light-duty, gasoline vehicles. Recognizing the significant source of VOC emissions from recreational spark ignited engines, California has recently tightened evaporative emission requirements for gasoline marine engines over 30 kW. These more stringent marine evaporative emission standards for larger engines will be introduced starting in 2018 and include new fuel hose, tank, venting, and fuel injection requirements. Additional, more stringent fuel hose permeation limits will start in 2020. In 2013, ARB adopted more stringent evaporative standards for recreational motorcycles that will require low permeability tanks and hoses, as well as carbon canisters to achieve the new 1 g/day total organic gas emission limit starting in 2018. EPA should review their evaporative emission requirements for all classes of off-road, gasoline engines and revise them to ensure that best available evaporative emission technologies are used in these applications.

On-road motorcycles are relying on three-way catalysts in the U.S. to comply with ARB's 2008 and EPA's 2010 exhaust emission standards. However, the exhaust and evaporative emissions of these catalyst-equipped on-road motorcycles will still be at levels considerably higher than late model, light-duty gasoline cars and trucks. Additional HC + NOx reductions can be obtained from on-road motorcycles through the use of engine, exhaust, and evaporative emission control strategies employed on today's best-in-class light-duty gasoline vehicles. In late 2012, the European Council adopted more stringent Euro 5 standards for two and three-wheeled vehicles to go into effect in 2020. These future standards will include much tighter NOx emissions (60 mg/km) as well as PM emissions (4.5 mg/km) and will bring motorcycle emissions limits on par with modern passenger cars.

Conclusion

In closing, we believe that there are numerous proven strategies available to further reduce hydrocarbon and NOx emissions from mobile source engines to meet the most stringent ozone ambient standards under consideration by EPA. The emission inventory modeling contracted by MECA, using the MOVES and NONROAD models forecasted the NOx reduction benefits in 2025 and 2050 of three potential NOx reduction strategies applied to heavy-duty and light-duty vehicles and equipment. Our analysis concludes that reduction of ozone precursors, such as HC and NOx, from the mobile sector, under the three control scenarios that were modeled (heavy-duty low NOx standards and California gasoline aftermarket catalysts), can deliver over 345,000 tons/year of NOx reductions in 2050 for the 65/60 ppm alternate standard region. When extended to the 47 contiguous states plus the District of Columbia and excluding California, the opportunity to reduce ozone precursors using the three control scenarios grows to nearly 500,000 tons per year in 2050 and represents the largest opportunity to reduce NOx from mobile sources. These reductions can be achieved extremely cost effectively at approximately $2,900/ton (NOx weighted average), relative to EPA's cost effectiveness threshold of $15,000 per ton of NOx used in the ozone NAAQS RIA. These mobile control strategies are cost competitive compared to the cost benefits of stationary control options included in the ozone NAAQS RIA with a NOx weighted average of approximately $3,700/ton for the 65/60 ppm scenario. Once appropriate health-based standards and corresponding NOx regulations 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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