WRITTEN COMMENTS OF THE
MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION
ON THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S PROPOSED RULE – CONTROL OF AIR POLLUTION FROM MOTOR VEHICLES: TIER 3 MOTOR VEHICLE EMISSION AND FUEL STANDARDS

July 1, 2013

MECA is pleased to provide written comments in support of the U.S. EPA's proposed Tier 3 light-duty vehicle emission and fuel standards. These proposals, when finalized, will reset the bar for state-of-the-art exhaust and evaporative emission controls for light-duty vehicles through 2025, and provide significant public health benefits to the citizens of the U.S. The proposals will also require the oil industry to produce and sell ultra-low sulfur gasoline that will result in immediate and significant emission reductions from the hundreds of millions of light-duty vehicles operating every day on America's highways, and ensure future fuel-efficient gasoline vehicles can comply with EPA's proposed Tier 3 emission limits. MECA applauds EPA for developing a Tier 3 proposal that will establish a national set of exhaust and evaporative emission standards for light-duty and medium-duty vehicles by largely harmonizing their proposal with California's LEV III requirements.

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 exhaust and evaporative emission controls for gasoline and diesel light-duty vehicles in all world markets. Our industry has played an important role in the emissions success story associated with light-duty vehicles in the United States, and has continually supported efforts to develop innovative, technology-forcing, emissions programs that have provided important public health benefits here in the U.S. and served as model programs in countries around the globe. The mobile source emission control industry has generated hundreds of billions of dollars in U.S. economic activity since 1975 and supports more than 65,000 U.S. jobs, mostly in product development and manufacturing. EPA's proposed Tier 3 emissions and fuel standards will provide additional support for the continued development of a thriving U.S. industry focused on a wide range of technologies that can reduce vehicle criteria emissions.

MECA agrees with EPA staff's assessment that achieving the proposed Tier 3 exhaust and evaporative emission standards and associated emission reductions are both technically feasible and cost-effective. This fact is clearly demonstrated by the more than two million SULEV- and PZEV-compliant light-duty vehicles that have been sold in the U.S. market since these near-zero emission, gasoline vehicles were first introduced more than ten years ago. This technology base of advanced three-way catalysts, exhaust hydrocarbon adsorber materials, high cell density substrates, emission system thermal management strategies, secondary air injection systems, advanced carbon canisters, advanced low fuel permeation materials, and air intake hydrocarbon adsorber materials that have already been commercialized for a variety of PZEV gasoline vehicle applications can be extended and further optimized to allow all light-duty and

medium-duty gasoline vehicles to achieve the exhaust and evaporative emission reductions needed to comply with the Tier 3 vehicle emission proposals put forward by EPA. On the exhaust side, Tier 3/LEV III emission technologies (including advanced three-way catalysts, advanced high cell density substrates, and hydrocarbon adsorber catalysts) are highlighted in a new MECA report entitled: "LEV III and Tier 3 Exhaust Emission Control Technologies for Light-Duty Gasoline Vehicles" (available on MECA's website, www.meca.org, under Resources >> Reports). A recent SAE paper (SAE paper no. 2011-01-0301) demonstrates how advanced three-way catalysts utilizing high cell density substrates can be combined to achieve Tier 3, Bin 20 or Bin 30, exhaust emission levels on a four-cylinder, light-duty gasoline vehicle. A 2013 SAE paper (SAE paper no. 2013-01-1297) provides insights into recent improvements in performance and durability of hydrocarbon adsorber catalysts. These latest generation hydrocarbon adsorber catalysts show improved cold-start hydrocarbon emission reductions with reduced precious metal content compared to earlier generations of hydrocarbon adsorber catalysts. Hydrocarbon adsorber catalysts are available to assist in difficult Tier 3 applications, such as larger weight trucks and SUVs.

Advanced evaporative emission technologies (including advanced carbon canisters and air intake hydrocarbon adsorbers) that are available to meet Tier 3/LEV III evaporative emission standards for light-duty or medium-duty gasoline or flex-fuel vehicles are discussed in the MECA report: "Evaporative Emission Control Technologies for Light-Duty Gasoline Vehicles" (available on MECA's website, www.meca.org, under Resources >> Reports). MECA worked closely with ARB in developing the LEV III canister bleed emission testing protocol (also included in EPA's Tier 3 proposal) that provides a cost-effective means of defining the bleed emission performance characteristics of carbon canisters used on light-duty or medium-duty gasoline vehicles. Including this canister bleed emission test procedure in the Tier 3/LEV III requirements ensures that vehicle manufacturers have to meet a minimum canister performance level in complying with the "zero" evaporative standards that California first put in place for PZEV-certified vehicles. As on the exhaust side, the millions of PZEV-certified vehicles operating on U.S. highways today form a solid evaporative technology base that can be extended to all future Tier 3/LEV III light-duty and medium-duty vehicles.

In addition, advanced diesel emission control technologies, including diesel particulate filters (DPFs), lean NOx adsorber catalysts, and selective catalytic reduction (SCR) catalysts, will be combined with future, advanced diesel engines to allow light-duty diesel vehicles to achieve the proposed Tier 3 emission limits, including EPA's proposed Tier 3, Bin 30 exhaust standards. Two recent research programs have discussed pathways to reaching Tier 3, Bin 30 exhaust standards with a light-duty diesel vehicle. The first of these is the Cummins Advanced Technology Light-Duty Diesel Aftertreatment System (ATLAS) program, sponsored by the U.S. Department of Energy (DOE). Details of this project were presented at the 2012 DOE DEER Conference held in Dearborn, MI (see: www1.eere.energy.gov/vehiclesandfuels/resources/proceedings/2012_deer_presentations.html, presentation by Mr. Cary Henry, Cummins, Inc.) and included in SAE paper no. 2013-01-0282 that was presented at the April 2013 SAE International Congress in Detroit, MI. Advanced diesel emission control technologies, including a passive lean NOx adsorber and an SCR-coated DPF that utilizes direct ammonia reductant injection, have been combined in this program with advanced combustion controls on a 2.8 liter, 4 cylinder diesel engine to demonstrate a pathway

to Tier 3, Bin 30 exhaust emissions compliance on a full-size, light-duty pick-up truck. A second approach to Tier 3, Bin 30 exhaust levels on a light-duty diesel vehicle was discussed by Southwest Research Institute in SAE paper no. 2013-01-1301 (presented at the April 2013 SAE International Congress in Detroit, MI). This project combines advanced diesel combustion technologies, including high temperature glow plugs, with a close-coupled lean NOx adsorber catalyst + catalyzed DPF emission system to significantly reduce cold-start emissions and provide a pathway to Tier 3, Bin 30 exhaust emission compliance on a 2 liter diesel-equipped sport-utility vehicle.

MECA generally agrees with EPA's cost estimates for achieving Tier 3 exhaust and evaporative emissions compliance on light-duty and medium-duty vehicles. These EPA Tier 3 cost estimates are in-line with the cost estimates developed by California as part of their LEV III rulemaking effort. Given that the Tier 3 vehicle cost estimates associated with advanced exhaust and evaporative emission technologies were assembled approximately two years before the proposal was publicly released, MECA would encourage EPA to update these costs with the latest projections from the automobile industry and emission control industry. MECA agrees with EPA's projections that future hydrocarbon adsorber catalyst applications will be targeted at larger light-duty vehicles. MECA believes that any Tier 3 applications of hydrocarbon adsorber catalysts will rely on "passive" hydrocarbon adsorber approaches that combine a hydrocarbon adsorber function with a three-way catalyst function on the same substrate (typically in a layered coating architecture in an underfloor converter location), rather than "active" hydrocarbon adsorber designs that utilize some type of an exhaust valve to direct the exhaust through a hydrocarbon adsorber material during cold-start. Passive hydrocarbon adsorber catalysts can provide effective cold-start hydrocarbon emission reductions at a significant cost advantage versus active hydrocarbon adsorber system designs. MECA also believes that manufacturers will have the opportunity to optimize emission system designs with advanced powertrains as they move forward with their future light-duty vehicle greenhouse gas compliance strategies. Strategies such as engine downsizing, vehicle weight reductions, and improved engine combustion technologies will help to off-set emission system cost increases for future Tier 3 compliance.

MECA strongly supported and agreed with ARB's decision to include a 1 mg/mile particle matter standard for light-duty vehicles over the FTP test cycle in their LEV III requirements. In the Tier 3 proposal, EPA proposed only to harmonize with the LEV III 3 mg/mile FTP PM standard and not propose a 1 mg/mile FTP PM standard. The 2012 decision by the European Commission to establish a particle number emission standard for light-duty vehicles powered by gasoline direct injection (GDI) engines as a part of their upcoming Euro 6 light-duty emission standards provides a more stringent particle emission limit for these GDI vehicles in the same time frame as the Tier 3/LEV III 3 mg/mile PM standard (proposed phase-in for the Tier 3, 3 mg/mile PM standard starts in 2017 and is fully phased-in with the 2021 model year; implementation of the Euro 6 GDI particle number limit of 6×10^{11} particles/km [equivalent to the Euro 5 light-duty diesel particle number limit], measured using the European PMP particle measurement protocol, begins in September 2017; see: ec.europa.eu/enterprise/sectors/automotive/documents/directives/motor-vehicles/index_en.htm). This European light-duty GDI particle number limit will cause auto manufacturers to introduce cleaner technologies, such as advanced fuel injection systems and/or gasoline particulate filters,

to comply with the European Euro 6 GDI particle number limit. Auto manufacturers are already working to bring forward early introductions of these ultra-low PM, Euro 6-compliant gasoline engines to the European market in the coming 12 to 18 months (European member states are permitted to introduce tax incentives for early introductions of Euro 6 vehicles prior to the first implementation dates of September 2014 for new models and September 2015 for all passenger car models). Nearly all auto manufacturers that sell into the European market are working with MECA members on potential applications of particulate filters on gasoline direct injection vehicles.

Gasoline particulate filters (GPFs) are based on the same, wall-flow ceramic filters that have been successfully applied on millions of light-duty and heavy-duty diesel vehicles in Europe and the U.S. for more than 10 years. The performance and application of these gasoline particulate filters has been highlighted in a number of recent technical publications in both the U.S. and Europe (e.g., SAE paper nos. 2010-01-0365, 2011-01-0814, and 2013-01-0836; SAE paper no. 2013-01-0527 authored by Environment Canada and MECA). Like diesel particulate filters, gasoline particulate filters are capable of reducing particle emissions by more than 85% over a wide range of particle sizes, including high capture efficiencies for ultra-fine particulates. The application of a GPF on a four-cylinder gasoline direct injection vehicle is expected to cost approximately $100-120 (see ICCT's GPF cost estimate available here: www.theicct.org/estimated-cost-gasoline-particulate-filters), making this emission control technology a cost-effective solution for reducing particulate emissions from future gasoline vehicles. When these filters are properly designed, the impact of a GPF installation on the backpressure and fuel-efficiency of the vehicle is expected to be minimal.

EPA needs to make sure that these same ultra-low PM, Euro 6 GDI engine/emission technologies are also utilized in the U.S. To that end, MECA believes that it is important for EPA, at a minimum, to harmonize with ARB's LEV III, 1 mg/mile light-duty vehicle PM FTP standard to maximize the public health benefits associated with reducing public exposure to particulate emissions from future light-duty vehicles. Some consideration should also be given to aligning with the European Euro 5/Euro 6 diesel/GDI particle number limit, especially if EPA and ARB believe that there are measurement issues with a 1 mg/mile PM standard. Based on information presented by ARB at the 2013 CRC On-Road Vehicle Emissions Workshop held in San Diego in April 2013 and presented to MECA in May 2013, ARB believes that there is a pathway to measuring PM emissions at levels below 1 mg/mile. ARB has published a revised PM mass measurement protocol that is part of their pathway to measuring very low PM mass levels from the exhaust of a vehicle (see ARB test method MLD 145 available at: www.arb.ca.gov/testmeth/slb/exhaust.htm). Ford researchers have also developed a correlation between particle number measurements and particle mass that can provide an alternative pathway to measuring very low PM mass levels (see M. Matti Mariq and Ning Xu, *Aerosol Science* 35 (2004), pp. 1251-1274). ARB adopted their 1 mg/mile PM standard to provide additional public health protection to exposure to particulate emissions from vehicle emissions and EPA needs to follow California's lead in harmonizing with this very tight PM standard. EPA and ARB need to continue to work together and reach agreement on measurement protocols that are acceptable for use with a 1 mg/mile FTP PM standard.

With respect to the proposed PM limits for the supplemental FTP test cycles, EPA acknowledged that their Tier 3 proposal is flawed by a dataset that included contamination with respect to the PM analyses that were done on Tier 2-compliant vehicles. ARB shared with MECA in late May 2013 some of the revised, corrected Tier 2/LEV II US06 test cycle results. These data support a much tighter PM standard for the US06 test cycle than proposed by EPA for Tier 3. MECA understands that ARB intends to propose that EPA set a Tier 3 US06 PM limit of approximately 4 mg/mile for all light-duty vehicles (as opposed to the proposed Tier 3 US06 PM limits that depend on vehicle weight) based on the testing they are expected to complete before July 1, 2013. MECA is supportive of ARB's Tier 3 comments on this subject and asks that EPA (and ARB) set the tightest, feasible US06 PM standard in their final Tier 3 regulation.

It is important for the United States to continue to set the bar on light-duty vehicle emission standards in order to encourage the development and use of best available control technologies for light-duty vehicles. EPA has a long history of setting technology-forcing vehicle standards based on the public health benefits they provide and this leadership needs to continue with respect to light-duty vehicle particle emission standards.

A critically important element to ensuring that future gasoline vehicles will be able to comply with EPA's proposed Tier 3 emission limits is EPA's proposed reduction of gasoline fuel sulfur levels to a 10 ppm national average starting in 2017. Numerous published studies have documented fuel sulfur-related deactivation of three-way catalysts that are the primary exhaust emission control technology used on light-duty and medium-duty gasoline vehicles. The negative impacts of gasoline fuel sulfur content on catalytic emission controls are highlighted in a newly revised MECA report: "The Impact of Gasoline Fuel Sulfur on Catalytic Emission Control Systems" (available on MECA's website, www.meca.org, under Resources >> Reports).

EPA has released a thorough and well-designed sulfur effects study on 81 in-use Tier 2 light-duty gasoline vehicles that clearly showed significant reductions in criteria pollutants in comparing emissions performance on gasoline with 28 ppm sulfur versus 5 ppm sulfur. Work published in a 2011 SAE technical paper (SAE paper no. 2011-01-0300) shows similar, significant emission benefits on a 2009 model year PZEV vehicle operated with 3 ppm sulfur gasoline versus 33 ppm sulfur gasoline. In this gasoline sulfur effects study, on a 2009 PZEV passenger car, the results clearly show that the underfloor converter used on the close-coupled + underfloor PZEV catalytic converter system was susceptible to sulfur-related performance degradation due to its cooler operating temperatures during the FTP test cycle using a 33 ppm sulfur-containing gasoline. The loss in NOx performance of this underfloor PZEV converter in successive FTP tests could be recovered to some extent, or avoided to a large degree, by either purging stored sulfur off the underfloor converter with the use of a higher speed and load test cycle (i.e., the US06 test cycle) sandwiched between FTP tests, or using a gasoline with significantly lower sulfur levels (i.e., a 3 ppm sulfur-containing gasoline).

In a MECA study published in a 2007 SAE paper (SAE paper no. 2007-01-1261), an advanced three-way catalyst system installed on a large 2006 V8-powered SUV showed clear evidence of sulfur deactivation in successive FTP testing with aged catalysts using 17 ppm sulfur gasoline. FTP emissions for this full-size SUV started at the proposed Tier 3, Bin 50 levels and

increased to slightly above proposed Bin 70 levels by the third FTP test, an emissions increase of more than 80% over three FTP tests. Sulfur deactivation of three-way catalysts negatively impacts the active precious metal catalysts, oxygen storage materials, and other activity promoters found in these sophisticated catalysts. The coverage and negative impacts of sulfur poisons on a three-way catalyst depends, in part, on the temperature history of the catalytic converter(s) found on the vehicle. Fuel sulfur deactivation of three-way catalyst is most apparent at lower exhaust temperatures (e.g., catalyst temperatures of less than about 500 degrees C). Sulfur deactivation of catalysts can be reversed to some degree by exposing catalysts to higher exhaust temperatures. Exhaust temperatures are expected to cool in the future as manufacturers reduce vehicle waste heat to meet future vehicle fuel efficiency/greenhouse gas standards. These cooler catalytic converter operating temperatures cause catalysts to accumulate higher amounts of sulfur poisons with today's gasoline sulfur levels, resulting in higher emission levels of pollutants at the tailpipe, including ozone-forming exhaust pollutants like hydrocarbons and NOx. Ultra-low gasoline sulfur levels of 10 ppm on average are needed to ensure that manufacturers will be able to meet the proposed Tier 3, Bin 30 fleet average emission standards over their 150,000-mile useful life for the full range of light-duty vehicles that consumers wish to buy and manufacturers want to produce.

MECA agrees with EPA's assessment that the cost of lowering average gasoline sulfur levels from today's 30 ppm national average to the proposed 10 ppm national average is on the order of one penny per gallon of fuel. EPA's gasoline cost assessment is supported by gasoline cost studies commissioned by the National Association of Clean Air Agencies (NACAA) and the Emission Control Technology Association (ECTA) that also indicate that costs for reducing gasoline sulfur levels to a 10 ppm national average are approximately one penny per gallon.

In addition to the need for a 10 ppm national average sulfur limit on gasoline for compliance with EPA's proposed Tier 3 emission standards, the availability of ultra-low sulfur gasoline will also open up opportunities for vehicle manufacturers to develop and commercialize lean gasoline engines that can provide improved fuel economy benefits relative to stoichiometric gasoline engines. A number of manufacturers are offering lean gasoline engine options in Europe and are interested in using this lean combustion approach to meet more stringent, future U.S. fuel economy/greenhouse gas emission standards. Lean gasoline engines will require the use of a lean NOx emission control technology to comply with proposed Tier 3 emission standards. Lean NOx adsorber catalysts are being used in Europe (where the gasoline sulfur cap is 10 ppm) on lean gasoline engines to reduce NOx emissions from these lean engines. Lean NOx adsorber catalyst performance is significantly impacted by gasoline fuel sulfur levels – the NOx adsorber function of these catalysts also strongly adsorb sulfur constituents present in the exhaust. Ultra-low sulfur gasoline is an important enabler for maximizing the performance of lean NOx adsorber catalysts, minimizing the duration and frequency of NOx adsorber desulfation events, and maximizing the potential fuel economy benefits of lean engine operation. A recent SAE publication (SAE paper no. 2013-01-1299) describes recent efforts to optimize the performance and desulfation characteristics of lean NOx adsorber catalysts that are targeted for a light-duty lean gasoline engine application. A national 10 ppm gasoline sulfur average requirement will provide manufacturers with the opportunity to use lean gasoline engine technology as an option for meeting future U.S. fuel efficiency/greenhouse gas standards.

MECA has consistently supported the introduction of the lowest possible fuel sulfur limits used with mobile sources to enable the use of best available exhaust emission controls and minimize the impacts of fuel sulfur on catalyst performance and durability. Adoption of a 10 ppm average gasoline sulfur limit by EPA will bring the U.S. in line with other major vehicle markets in Europe, Japan, South Korea, and China where 10 ppm gasoline and diesel fuel sulfur caps are already in place or will be in place by 2018. MECA is supportive of a 20 ppm gasoline sulfur cap for Tier 3 that would be aligned with California's current gasoline sulfur cap. However, MECA also appreciates the importance of providing some compliance flexibilities to the oil and refining industries (as EPA has done in past fuel sulfur regulations) to facilitate cost-effective compliance with the standards. MECA believes that a 10 ppm average gasoline sulfur standard with a gasoline sulfur cap of no higher than 50 ppm provides the refining industry with an adequate, cost-effective compliance pathway. MECA also supports defining fuel sulfur average limits or caps on any alternative transportation fuels (e.g., blends of alcohols with gasoline, natural gas) that are consistent with the proposed 10 ppm national average for gasoline or the existing 15 ppm national sulfur cap on diesel fuel.

MECA is pleased that EPA has included a testing protocol for quantifying dioxin and furan emissions from the exhaust of vehicles in their Tier 3 proposal. MECA partnered with EPA in completing a dioxin/furan test program on a heavy-duty diesel engine equipped with advanced base-metal SCR catalysts (both flow-through SCR catalysts and SCR catalysts coated on particle filter substrates) that included the development of the dioxin/furan testing method published in EPA's Tier 3 proposal. MECA believes that it is important for other emissions laboratories to gain experience with this EPA mobile source dioxin/furan testing method and suggests that EPA consider conducting some type of round-robin testing with this protocol at recognized industry emissions-testing laboratories.

In summary, there are significant opportunities to reduce both criteria pollutant and greenhouse gas emissions from the transportation sector through the design of fuel-efficient powertrains that include advanced exhaust emission controls for meeting even the most stringent criteria pollutant standards that are included in EPA's proposed Tier 3 program. MECA believes that advanced emission control systems have a critically important role in future policies that aim to reduce mobile source criteria pollutant and greenhouse gas emissions. MECA strongly supports EPA's Tier 3 emissions and fuel standards proposal. In addition, MECA asks EPA to harmonize with ARB's 1 mg/mile FTP PM standard and to set tighter PM limits for the US06 test cycle. Finally, MECA urges EPA to finalize these proposals by the end of this year.

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