WRITTEN COMMENTS OF THE
MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION
ON THE AUSTRALIAN GOVERNMENT'S
VEHICLE EMISSIONS DISCUSSION PAPER

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The Manufacturers of Emission Controls Association (MECA) is pleased to provide input to the Australian Government's February 2016 Vehicle Emissions Discussion Paper. MECA recommends that Australia move forward with introducing tighter vehicle standards for both noxious emissions and greenhouse gases for both new light-duty and heavy-duty engines and vehicles. Aligning Australia's vehicle emissions and fuel quality standards with the Euro 6/VI light-duty and heavy-duty standards, at a minimum, will provide significant economic, climate change and health benefits for the citizens of Australia. Even more public health and climate change protective vehicle emission standards are in place, in most cases, in the United States and Canada, and Australia could maximize the public health and climate change benefits for Australia by taking advantage of the many cost effective vehicle emissions and efficiency technologies that have already been developed and commercialized for the U.S. and Canadian markets. MECA has compared the essential provisions of the European and U.S. vehicle regulatory framework with respect to noxious pollutants in a table that can be found on our website at: http://www.meca.org/regulation/mobile-source-regulatory-comparison.

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 as well as heavy-duty engines in all world markets. Our industry has played an important role in the emissions success story associated with light and heavy-duty vehicles in North America, and has continually supported efforts to develop innovative, technology-forcing, emissions programs to deal with unique air quality problems such as those found in an increasing number of Australian metropolitan areas.

In the heavy-duty sector the largely equivalent Euro VI and U.S. 2010 engine emission standards build on the extensive, successful experience with diesel particulate filters (DPFs) for controlling diesel particulate emissions, and selective catalytic reduction (SCR) technology for controlling NOx emissions that spans more than 15 years in the major vehicle markets of the United States, Canada, Europe, and Japan. DPFs and SCR technology have been used on millions of heavy-duty engines and vehicles to provide cost-effective, durable reductions of diesel PM and NOx emissions. A recent report published by the International Council on Clean Transportation (ICCT), with input from MECA, details the costs associated with Euro VI/U.S. 2010 emissions compliance. This ICCT study is available here: http://theicct.org/costs-emission-reduction-tech-hdvs. It is important to note that an important enabler to compliance with Euro VI/U.S. 2010 heavy-duty engine emission standards is the use of ultra-low sulfur diesel fuel (sulfur levels capped at 10-15 ppm sulfur), a clean fuel that is already in place in Australia. Detailed information about the types of diesel emission control technologies being deployed on

heavy-duty diesel engines can be found in MECA's diesel technology report here: http://www.meca.org/galleries/files/MECA_Diesel_White_Paper_12-07-07_final.pdf.

The recent Advanced Collaborative Emission Study (ACES, reports available at: http://crcao.org/publications/emissions/index.html) completed in the U.S. demonstrated the effectiveness of DPF technology on 2007 commercial heavy-duty diesel engines from four of the major U.S. manufacturers, all equipped with DPFs. The 2007 OEM-equipped DPF technology reduced PM emissions by over 99 percent (90 percent below the standard). When these filters are catalyzed, they reduce HC emissions, polycyclic-aromatic hydrocarbons (PAHs), dioxins and other toxics by 80 percent or more from their engine-out levels. The second phase of the ACES study evaluated three commercial 2010 technology heavy-duty diesel engines with both DPF and SCR technology and showed a further performance improvement above and beyond the 2007-compliant engines of an additional 70 percent lower PM emissions, including a further 70 percent reduction in ultrafine particles as represented by particle number emissions. This result was supported by a separate European study that demonstrated that these advanced wall-flow DPFs not only capture over 99 percent of the soot particles in the PM2.5 range, they are even more efficient at capturing over 99.8 percent of ultrafine particles. Ultrafine particles in the less than 100 nanometer size range contribute almost nothing to the overall mass of PM in the exhaust however; they may represent a huge number of particles with an extremely high surface area. Ultrafine particle toxicity has been the focus of numerous health studies that have shown that these ultrafine particles may pose the greatest adverse health effects due to their high surface area that can attract volatile toxic compounds and their ability to penetrate deep into the lungs.

The ACES study results demonstrate that diesel particulate filters greatly reduce the amount of PM from modern diesel engines and that the overall toxicity of exhaust from modern diesel engines is significantly decreased compared with the toxicity of emissions from older, non-DPF-equipped diesel engines (see the Health Effects Institute's ACES study executive summary available at: http://pubs.healtheffects.org/view.php?id=447). Co-benefits of DPF filters include the capture or oxidation of the majority of ash, carbonaceous or volatile ultrafine particles present in the exhaust that includes significant reductions in black carbon emissions, a serious short term climate change pollutant (see the California Air Resources Board funded study highlighting the significant impact of reducing black carbon emissions from diesel engines on climate change, released in June 2013, available at: http://www.arb.ca.gov/research/single-project.php?row_id=64841).

With diesel engines equipped with DPF+SCR systems, the importance of proper engine maintenance cannot be overemphasized for the durability and long term performance of the vehicle and the DPF+SCR emissions system. A May 2015 report from the California Air Resources Board summarizes the durability experience with DPFs on heavy-duty trucks that have been installed either by original equipment manufacturers or retrofit on older trucks (see: http://www.arb.ca.gov/msprog/onrdiesel/documents/DPFEval.pdf). This California study found that DPFs are operating properly and effective in removing more than 98% of toxic diesel PM emissions. Engine durability issues and inadequate maintenance practices were found to be the primary reasons for observed problems with DPFs. Regular maintenance becomes critical once a DPF+SCR system is installed because the presence of smoke in the exhaust can no longer be used as an indicator of engine operation problems. High smoke opacity could be a sign of

excessive oil consumption or a bad fuel injector, both of which result in high engine-out PM that may lead to plugging of the filter. Once a DPF is installed in the exhaust system, it will capture the PM and mask any signs of high smoke. The California Air Resources Board has recently initiated an effort to identify best maintenance practices for heavy-duty engines and Australia should utilize information under development in California to inform truck and bus owners of the importance of utilizing effective, preventive maintenance practices. Similarly, CARB is exploring alternate measurement methods for inspection and maintenance of DPF filters on heavy-duty trucks. We recommend Australia to follow these developments and consider including PM or PN measurements as part of any future, in-use heavy-duty compliance program.

In the light-duty gasoline vehicle sector Euro 6/U.S. Tier 2/U.S. Tier 3 noxious emission standards build on the extensive experience and success with advanced three-way catalysts. Euro 6 gasoline exhaust standards are roughly equivalent to U.S. Tier 2 exhaust standards, but less stringent than U.S. Tier 3 exhaust standards. The Euro 6 evaporative emission standards for gasoline vehicles are significantly less stringent than U.S. Tier 2 or Tier 3 enhanced evaporative emission standards. The public record (including technical support provided by MECA) associated with both the U.S. EPA's Tier 2 and Tier 3 exhaust and evaporative emission standards for gasoline vehicles provides solid evidence that these standards are technically feasible and cost effective (see: https://www3.epa.gov/tier2/ for details of the U.S. EPA's Tier 2 light-duty standards; and https://www3.epa.gov/otaq/tier3.htm for details on EPA's Tier 3 standards) . This fact is clearly demonstrated by the millions of light-duty gasoline vehicles certified to Super Ultra-low Emission Vehicle (SULEV) and Partial Zero Emission Vehicle (PZEV) equivalent standards that have been sold in North America since these near-zero emission, gasoline vehicles were first introduced more than ten years ago. The technology base of advanced three-way catalysts, high cell density substrates, thermal management strategies, secondary air injection systems, advanced carbon canisters and advanced low fuel permeation materials that have already been commercialized for gasoline vehicle applications in North America can be readily applied to gasoline vehicles in Australia to provide noxious emission reductions beyond current Euro 6 standards. MECA has provided an overview of the types of exhaust emission control technologies that are being deployed in North America and Europe to meet the tightest emission standards for light-duty gasoline vehicles in our whitepaper that can be found here: http://www.meca.org/resources/LEV_III-Tier_3_white_paper_0215_rev.pdf from our website www.meca.org (under Resources, then Reports). A recent Society of Automotive Engineer's technical paper (SAE paper no. 2011-01-0301) demonstrates how advanced three-way catalysts utilizing high cell density substrates can be combined to achieve the lowest available U.S. Tier 3 exhaust emission limits (Tier 3, Bin 20 or Bin 30 limits of approximately 20 or 30 mg/mile NMOG+NOx emissions over the U.S. FTP test cycle [or approximately 30-50 mg/km NMOG+NOx]) on a four-cylinder, light-duty gasoline vehicle.

Similar to the diesel case, ultra-low sulfur gasoline levels are a pre-requisite to deliver meaningful reductions in noxious emissions from both existing and future gasoline vehicles in Australia. Australia should follow the lead of Europe and the U.S. in reducing gasoline fuel sulfur levels to around the 10 ppm level as part of any future tightening of light-duty gasoline vehicle emission standards. The negative impacts of gasoline sulfur levels on the performance and durability of three-way catalysts is well documented and was included in MECA's written comments on the U.S. EPA's proposed Tier 3 light-duty emission standards (see MECA's July 1,

2013 and August 22, 2013 written comments on EPA's proposed Tier 3 light-duty vehicle emissions and fuel standards available at: http://www.meca.org/news/testimony. Improved three-way catalyst performance and durability is observed even in reducing gasoline fuel sulfur levels from 30 ppm to 10 ppm. MECA's June 2013 report on "The Impact of Gasoline Fuel Sulfur on Catalytic Emission Control Systems," available at: http://www.meca.org/resources/reports (under Fuels) reviews the wealth of information published on the negative interactions between gasoline sulfur and precious metal-containing three-way catalysts. Due to the largely reversible impacts of gasoline fuel sulfur, reducing gasoline fuel sulfur levels to the ultra-low levels recommended here, can provide significant and nearly immediate emissions benefits to the existing fleet of Australian light-duty gasoline vehicles.

One facet of the Euro 6 light-duty standards for gasoline vehicles that is more stringent than the U.S. Tier 2 or Tier 3 light-duty standards is with respect to particle emissions from gasoline direct injection (GDI) engines. Due to the tendency of GDI engines to emit large amounts of PM, in 2011, the European Commission established a particle number emission standard for light-duty vehicles powered by gasoline direct injection (GDI) engines as a part of their upcoming Euro 6c light-duty emission standards. This PN standard is set at 6 X 10^{11} particles/km, starting in September 2017, measured using the European PMP particle measurement protocol; see: http://circa.europa.eu/Public/irc/enterprise/automotive/library?l=/technical_committee/december_confirmed/text-02122011pdf/_EN_1.0_&a=d.). This level of particle number emissions has been estimated to be approximately equivalent to 0.3 mg/km on a mass basis in MECA's ultrafine particle report (see: "Ultrafine Particulate Matter and the Benefits of Reducing Particle Numbers in the United States," published in July 2013 under Reports at: http://www.meca.org/resources/reports). This Euro 6c GDI particle number standard is approximately 20 times more stringent than the current U.S. Tier 2 PM limit, six times more stringent than the U.S. Tier 3 PM standard that begins its phase-in with model year 2017, and approximately twice as stringent as California's 0.6 mg/km light-duty PM standard that currently comes into effect starting with model year 2025. This European 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 6c GDI particle number limit.

Auto manufacturers are already working to bring forward early introductions of these cleaner Euro 6c-compliant gasoline engines to the European market in the coming 12 to 18 months. One manufacturer has already commercialized a vehicle that has both an advanced fuel injection system and an uncatalyzed gasoline particulate filter (GPF). 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 are based on the same, wall-flow ceramic filters that have been successfully applied on millions of diesel vehicles and engines in Europe and North America for more than 10 years. The performance and application of these GPFs has been highlighted in a number of recent technical publications (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 ultrafine

particulates. The application of a GPF on a four-cylinder gasoline direct injection vehicle is expected to cost no more than $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 has been shown to be minimal.

MECA strongly recommends that Australia consider the adoption of tighter, U.S.-style evaporative emission requirements for light-duty gasoline vehicles in the future. These tighter evaporative standards will require the use of advanced evaporative emission technologies such as; advanced carbon canisters, onboard refueling vapor recovery (ORVR) and low permeation materials that are being used to meet U.S. Tier 2 and future Tier 3 evaporative emission requirements for light-duty and medium-duty gasoline or flex-fuel vehicles. These technologies 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, then Reports). Weak Euro 4/5/6 evaporative emission standards for gasoline vehicles coupled with Australia's relatively warm climate creates a significant inventory of hydrocarbon emissions from gasoline vehicles associated with running fuel losses, diurnal events, and refueling events. A similar situation exists in China and now the Chinese are expected to include more stringent, U.S.-style evaporative emission standards in their next round of light-duty standards (so-called China National 6/VI or Beijing 6/VI vehicle emission standards). A detailed discussion in support of tighter evaporative standards, including ORVR, for the Chinese/Beijing light-duty vehicle fleet can be found on MECA's website here: http://www.meca.org/resources/November_2014_ORVR_Report_-_2-17-15_FINALv4_for_MECA.pdf. Australia can use the information in this report to understand the scope of their own evaporative emissions inventory and the potential hydrocarbon emission reductions available from adopting more stringent evaporative emission standards compared to those associated with the Euro 5/6 light-duty vehicle standards.

With respect to light-duty diesel vehicles, the U.S. Tier 2 and Tier 3 standards are significantly more stringent than the Euro 6 standards (including the addition of the Euro 6c real world driving emissions programs and associated compliance factors). Unlike the European light-duty diesel standards, U.S. Tier 2 and Tier 3 standards are fuel neutral, requiring light-duty gasoline and diesel vehicles to comply with the same exhaust emission standards. The Euro standards allow light-duty diesel vehicles to comply with a less stringent NOx standard compared to gasoline vehicles. Despite the recent issues associated with VW's highly publicized, light-duty diesel non-compliance problems in the U.S. and other world markets, light-duty diesels from other manufacturers have been successfully certified to the U.S. Tier 2 standards using a combination of DPF technology for controlling PM emissions and SCR technology for controlling NOx emissions (similar to the case for heavy-duty diesel engines that comply with Euro VI and U.S. 2010 regulations). These same diesel emissions technology combinations are expected to be front and center in Europe as manufacturers begin to comply with the Euro 6c real world driving limits in 2017. Continued evolution and enhancements to both DPFs and SCR technology are also expected to provide a pathway for diesel vehicles to comply with even more stringent U.S. Tier 3 light-duty standards in the future.

The ICCT has published estimated costs associated for both gasoline and diesel vehicles complying with either the Euro or U.S. exhaust emissions standards (through Euro 6 and U.S. Tier 2). MECA contributed to this compliance cost study also and believes that the ICCT estimates provide a good estimate for the exhaust emission control technologies associated with compliance to these light-duty regulations. The ICCT light-duty exhaust emissions compliance study is available at: http://theicct.org/estimated-cost-emission-reduction-technologies-ldvs.

The U.S. is also home to some of the most stringent light-duty and heavy-duty vehicle or engine fuel efficiency/greenhouse gas emission standards. These standards can serve as a model for future Australian vehicle efficiency standards. These efficiency standards have fostered the development and implementation of a myriad of efficiency technologies for both light-duty and heavy-duty vehicles including advanced engine combustion technologies, advanced emission control technologies, turbochargers, multi-speed transmissions, and hybrid powertrains for gasoline, diesel, and alternative fuel applications. Additional information on technologies for reducing greenhouse gas emissions from mobile source (including CO_2, nitrous oxide, methane, and black carbon) are available on MECA's website at: www.meca.org/technology, from the ICCT website (see: http://theicct.org/passenger-vehicles and http://theicct.org/heavy-duty-vehicles), and the U.S. EPA website (see: https://www3.epa.gov/otaq/climate/regulations.htm).

European Union regulations provide the most stringent emission regulations for motorcycles and mopeds. Euro 4 emission standards for motorcycles are being implemented in Europe in 2016, followed by even more stringent Euro 5 emission standards that begin in 2020. Three-way catalyst technology derived from light-duty gasoline vehicle applications, coupled with closed-loop air/fuel control and other engine-based controls enables motorcycles to achieve these Euro 4 and Euro 5 emission levels. Additional information on the regulatory landscape and emission control technologies available for motorcycles is provided by a MECA report available on our website under Resources, then Reports (see: http://www.meca.org/resources/reports, "Emission Control of Two- and Three-Wheel Vehicles," September 2014). Australia should follow Europe's lead in implementing these cost-effective Euro 4 and 5 motorcycle emission standards to further reduce noxious air pollutants from the mobile source sector.

The VW light-duty diesel emissions compliance story has also focused attention on the need for robust compliance and enforcement programs that ensure the vehicles and engines deliver the emissions and efficiency benefits that are associated with stringent mobile source emissions regulatory programs. The European Union has proposed strengthening their type approval, compliance, and enforcement activities in response to the current disconnect between vehicle emission standards and real world performance, and to better detect the illegal use of defeat devices by vehicle and engine manufacturers. The U.S. EPA and California Air Resources Board have also taken steps to include more real world driving conditions and on-board diagnostic reviews and interrogations in their emissions certification and compliance programs to provide additional scrutiny over manufacturers' complex software and hardware systems aimed at complying with stringent emissions and efficiency regulatory requirements. MECA believes that Australia should consider not only setting more stringent emissions and efficiency standards for new vehicles and engines but robust compliance and enforcement programs that ensure delivery of the air quality and climate change benefits that the citizens of Australia deserve and demand.

In conclusion, MECA believes that cost-effective technologies are available to deliver additional needed reductions in noxious emissions and further climate change benefits to the citizens of Australia. At a minimum, Australia should move forward with finalizing another round of light-duty and heavy-duty vehicle and engine noxious emission standards that follow the Euro 6/VI standards. Significant additional reductions in the light-duty sector are achievable by structuring a regulatory program that follows the U.S., fuel neutral Tier 2 or Tier 3 light-duty exhaust and evaporative emission programs. MECA recommends that if Australia chooses to adopt Euro 6/VI emission standards that serious consideration be given to including more stringent gasoline vehicle evaporative emission standards that are based on U.S. Tier 2 or Tier 3 evaporative standards to realize significant, cost-effective reductions to vehicle fuel-based hydrocarbon emissions. The U.S. light-duty and heavy-duty vehicle and engine efficiency standards also provide Australia with a good template for further reductions in greenhouse gas emissions. Once finalized, these regulations will provide the citizens of Australia with significant economic, air quality and climate change benefits. MECA encourages Australia to finalize their next set of vehicle emissions and efficiency regulations as soon as possible. If these regulations can be finalized in late 2016 or early 2017, these more stringent standards could begin their phased-in implementation by 2019 or 2020. Australia's commitment to move forward with more stringent emissions and efficiency standards for mobile sources also will set a powerful example for the rest of Southeast Asia to follow. MECA members stand ready to work with their customers to deliver the needed emission control and efficiency technologies that will allow future new passenger cars and trucks in Australia to comply with more stringent standards. MECA also recommends that Australia should insure that the emission reductions expected under existing and future standards for mobile sources are realized by implementing rigorous and robust compliance and enforcement programs.

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