Written Comments of the Manufacturers of Emission Controls Association on the U.S. Consumer Product Safety Commission's Proposed Rulemaking to Limit CO Emissions from Operating Portable Generators

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The Manufacturers of Emission Controls Association (MECA) is pleased to provide written comments on the U.S. Consumer Product Safety Commission's proposed rulemaking to limit carbon monoxide emissions from operating portable generators. MECA thanks CPSC for its efforts to develop a comprehensive proposal that effectively addresses the risk of injury associated with CO poisoning from portable generators. We believe the Commission's recommended maximum CO emission rates for portable generators are reasonable and can be met through the use of a variety of readily available technologies, including electronic fuel injection, closed-loop air/fuel control, and three-way catalyst technology.

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 – including electronic fuel injection systems, oxygen sensors for closed-loop control, and advanced catalyst and substrate technology – for a wide variety of on-road and off-road vehicles and equipment. In addition, our members have over 20 years of experience in the safe application of catalysts to a wide variety of on-road and off-road, small displacement, spark-ignited engines, like those used in portable generators.

MECA commends CPSC staff for its thorough technical work conducted in support of the proposed rulemaking, including staff's technology demonstration program. Based on this extensive analysis, CPSC staff concluded – and MECA agrees – that significant reductions in the CO emission rates of portable generators are technically feasible for each of the designated generator categories. Specifically, CPSC's analysis found that existing emission control technology – namely, closed-loop electronic fuel injection (EFI), engine calibration, and a small three-way catalyst – can be applied to the engines that power portable generators to significantly reduce their CO emission rate to a level that is expected to result in fewer deaths and injuries when used in scenarios that currently cause fatalities. MECA believes the levels of the maximum CO emission rates proposed by CPSC for the four designated generator categories are reasonable and can be met within the proposed time frames for compliance.

Catalyst technology for small spark-ignited (SI) engines draws from the more than 40 years of successful experience in the U.S. and around the world with catalytic converters applied to light-duty gasoline cars, trucks, and motorcycles. This precious-metal, three-way catalyst technology is capable of achieving significant reductions in hydrocarbon (HC), oxides of nitrogen (NOx), and carbon monoxide (CO) emissions. More recently, MECA members have been developing less expensive base-metal catalyst technology to effectively reduce these criteria pollutant emissions (comparable CO reductions compared to precious-metal catalysts).

Catalyst technology has also been successfully applied to a wide variety of small, two- and four-stroke SI engines, such as those used in handheld equipment (e.g., chainsaws, leaf blowers, string trimmers) and nonhandheld equipment (e.g., lawn mowers, motor scooters, motorcycles, marine engines, and forklift trucks). The successful application of catalysts to these small SI engines has required the engineering of exhaust systems that effectively manage exhaust component temperatures, provide for efficient packaging of the catalyst within the exhaust system and heat shielding to manage surface temperatures, include consideration for the safe operation of the engine in the environment, and have adequate mechanical and catalytic durability. All of this experience can be directly applied to the design of safe, effective, and durable emission control systems for portable generators.

The published experience of catalyst performance on four-stroke gasoline engines indicates that high efficiencies for reducing CO emissions are strongly influenced by the air/fuel stoichiometry in the exhaust upstream of the catalyst. Maximum reduction efficiencies for all three regulated pollutants (HCs, NOx, CO) can be obtained if the air/fuel ratio of the exhaust stream is controlled to be near the stoichiometric ratio of reducing and oxidizing components in the exhaust stream. At or near this stoichiometric air/fuel ratio, catalyst efficiencies can be well in excess of 90% for all three pollutants provided that the catalyst temperature is above its activation temperature (typically 350°C or higher), and that a reasonable catalyst volume relative to the volumetric flow of exhaust gas is contained in the system. The most widely used method for accurate, cost-effective air/fuel ratio control is through the use of fuel injector technology in combination with a closed-loop control strategy that employs an engine control unit and oxygen sensors in the exhaust upstream and downstream of the catalyst. The sensors provide a feedback loop to the engine's intake air and fuel metering system.

Closed-loop electronic fuel injection is an effective technology that can deliver not only an accurate air/fuel mixture to the cylinder for effective CO reduction and engine durability, but also offers a number of co-benefits to the manufacturer and consumer compared to a carbureted engine. For example, optimization of the air/fuel mixture by the EFI system can deliver maximum power and responsiveness from the engine. Other benefits of EFI include smoother and more consistent transient throttle response, easier cold-starting, more accurate adjustment to account for extremes of ambient temperatures and changes in air pressure, more stable idling, and decreased maintenance needs. Fuel injection also removes the need for a separate mechanical choke, which on carburetor-equipped engines must be adjusted as the engine warms up. Regardless of whether the air/fuel mixture is delivered via a carburetor or EFI, careful calibration of the engine is an important element to controlling catalyst efficiency and temperature.

Both the California Air Resources Board (ARB) and the U.S. Environmental Protection Agency (EPA) have evaluated the performance of catalysts on Class I (up to 225 cc cylinder displacement) and Class II (225 cc or greater cylinder displacement), gasoline four-stroke engines used in off-road applications of nonhandheld equipment. In these test programs, catalysts were shown to perform effectively, over extended hours of operation, in reducing HC, NOx, and CO exhaust emissions. The ARB test program was concluded in 2004 and a final report ("Durability of Low-Emissions Small Off-Road Engines") is available at: https://www.arb.ca.gov/msprog/offroad/sore/swri-final-report.pdf. EPA issued a report in 2006 on their technical study on the safety of emissions controls for nonroad SI engines less than 50 horsepower. A copy of this EPA report ("EPA Technical Study on the Safety of Emission Controls for Nonroad Spark-Ignition Engines <50 Horsepower") is available at: http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100KIWA.TXT.

The ARB and EPA studies show that catalysts can be integrated into the existing muffler designs used on these small engines and provide significant reductions in exhaust emissions. The ARB test program was completed in advance of ARB approving Tier 3 emission standards for Class I and Class II engines that began in 2007. The EPA safety study, conducted in support of the agency's work for developing the Phase 3 emission standards for small SI engines, addressed emission performance and safety issues with the implementation of catalysts on these small engines. In terms of emissions control, the focus for both the ARB and EPA test programs was the reduction of HC and NOx exhaust emissions from these small gasoline engines. CO emission performance of the catalyst system designs were also evaluated and ranged from 50% to greater than 70% depending on system design and air/fuel ratio of the exhaust components present at the inlet of the catalyst. Regarding the issue of heat management and the use of catalysts, it is well known that oxidizing HCs and CO across a catalyst raises the temperature of the catalyst. The EPA safety study focused on the application engineering needed to manage the surface temperature of the catalyzed mufflers so that they exhibit comparable surface temperatures as the uncatalyzed mufflers. The EPA safety study concluded that the application of catalysts to these small gasoline engines would not cause any incremental increase in risk of fire or burn to consumers. Techniques used to minimize engine and catalyst surface temperatures include cooling and shrouding of the engine and catalyst-muffler, the use of heat shielding and/or air-gap insulated exhaust components, and equipping the engine with an exhaust ejector over the exhaust outlet of the catalyst-muffler.

EPA also published an SAE paper in 2009 (see: http://papers.sae.org/2009-01-1899/) that summarizes a test program to demonstrate the feasibility of using engine management systems and high-efficiency exhaust catalysts for nonroad spark-ignition gasoline Class II engines. Low-cost electronic engine management and fuel injection systems were installed on two single-cylinder SI engines. Integrated catalyst-muffler systems were developed for both engines and fuel control was calibrated to achieve emission control goals while maintaining or improving fuel consumption, engine durability, and performance. EPA found that applying EFI in combination with the catalyst not only reduced HC+NOx emissions by 75% from these engines' stock carbureted configuration but also reduced CO by 65%.

It should be noted that small gasoline engines are often designed to operate in a net fuel-rich condition to limit combustion and exhaust temperatures as a means of managing engine component durability. In net fuel-rich exhaust conditions, high CO catalyst efficiencies can also be achieved through use of some type of air introduction into the exhaust downstream of the engine. This strategy is generally termed secondary air injection. Air injection into the exhaust shifts the air/fuel ratio of the exhaust to a leaner (more oxygen rich) condition upstream of the catalyst and favors oxidation of CO and hydrocarbons over the catalyst. Lean exhaust conditions, however, are less favorable for the reduction of NOx over a three-way catalyst. In larger engines, secondary air can be introduced in a well-controlled manner using an air pump. Both of the aforementioned ARB and EPA test programs include examples of the use of secondary air injection into the exhaust, typically through some type of passive, venturi-based approach. This approach was shown to be cost-effective on smaller engine categories that cannot justify or accommodate the size of an air pump.

MECA last year analyzed EPA's certification database for model year 2015 nonhandheld engines. Of the over a thousand engines listed, approximately 100 of these engines were certified with CO levels less than 50 g/kW-hr. Of the nine gasoline-fueled engines, all use catalysts (seven use closed-loop EFI and two are carbureted). The remaining low-CO engines are either natural gas or propane, some of which use catalysts. MECA is aware of two manufacturers of four-stroke, gasoline generators – Westerbeke Corporation and Kohler Power Group – who are already using properly designed exhaust systems with catalysts to reduce CO emissions by more than 90% compared to uncontrolled levels. Both of the companies have targeted marine applications for these ultra-low CO emission generators that achieve CO levels below 5 g/kW-hr. The ultra-low CO marine generators employ water-cooling and controlled air/fuel ratio near the stoichiometric point to achieve high CO conversion efficiencies across a catalyst while also protecting exhaust components from high temperatures.

Looking ahead, several portable generator manufacturers have announced that they will be introducing air-cooled, low-CO generators in 2017 in response to CPSC's proposed rule. Kohler announced in October 2016 that it would be rolling out a low-CO engine designed to be used in a wide array of utility equipment, including portable generators. The Kohler engine features a closed-loop EFI system and integrated catalytic exhaust system to significantly lower emissions. In addition, TTi, a manufacturer of EFI systems and portable generators, has said in public testimony that it plans to release multiple generators during 2017 with low-CO engines. The efforts of portable generator and engine manufacturers to deploy advanced control technologies into the marketplace depend on emission regulations such as the one being proposed by CPSC. Regulations create a level playing field in the marketplace for all manufacturers to deploy the most cost-effective solutions.

Finally, in addition to CPSC staff's low-CO emission technology demonstration program, staff also investigated ways to possibly mitigate the CO hazard through a system that would automatically shut off the engine before creating an unsafe CO exposure. Reviewing the results of CPSC staff's testing of shutoff devices in a variety of different usage scenarios, it appears that the effectiveness of a shutoff device can vary dramatically depending on the location and the orientation of the portable generator. Therefore, MECA believes that the use of existing emission control technology (i.e., closed-loop EFI and a three-way catalyst) would most effectively reduce the CO emission rate and reduce the CO poisoning hazard. It may be beneficial to also incorporate a shutoff device as a backup fail-safe device in conjunction with engine and exhaust CO controls should the operating conditions of a portable generator result in high CO levels within a confined space.

In conclusion, MECA commends CPSC for taking important steps to reduce CO emissions from portable generators. As demonstrated by several manufacturers, EPA, and ARB, as well as by CPSC staff in its technology demonstration program, the application of readily available technologies such as closed-loop electronic fuel injection and three-way catalyst technology to small nonroad spark-ignited engines used in portable generators is a cost-effective solution for reducing CO emissions from these engines. MECA is committed to do our part to ensure that these emission control, fuel-injection, and oxygen-sensor technologies are available to help meet CPSC's requirements.

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