Written Comments of the Manufacturers of Emission Controls Association (MECA) on the National Institute of Standards and Technology's (NIST) Report, "Technical Note 1781: Modeling and Measuring the Effects of Portable Gasoline Powered Generator Exhaust on Indoor Carbon Monoxide Level"

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The Manufacturers of Emission Controls Association (MECA) is pleased to provide our comments to the U.S. Consumer Product Safety Commission (CPSC) on the National Institute of Standards and Technology's (NIST) report, "Technical Note 1781: Modeling and Measuring the Effects of Portable Gasoline Powered Generator Exhaust on Indoor Carbon Monoxide Level." MECA is a non-profit association of the world's leading manufacturers of emission control technology for motor vehicles and stationary internal combustion engines. Our members have nearly 40 years of experience and a proven track record in developing and manufacturing emission control technology for a wide variety of on-road and nonroad vehicles and engines. A number of our members have extensive experience in the development, manufacture, and commercial application of carbon monoxide (CO) emission control technologies for stationary engines, as well as expertise in applying catalyst technologies to small, spark-ignited engines less than 25 hp.

MECA has been engaged in CPSC's efforts to improve the safety of portable generators in marine and domestic applications by reducing the level of CO emitted by these small, spark-ignited four-stroke engines. MECA has previously provided comments to CPSC about the available technology for portable generator applications in response to CPSC's request for information on techniques to reduce CO from gasoline portable generators (MECA letter dated April 28, 2006), MECA's written comments on CPSC's ANPRM on portable generators (comments dated February 11, 2007), and MECA's written comments on CPSC's September 2012 test report, "Technology Demonstration of a Prototype Low CO Emission Portable Generator" (comments dated November 7, 2012). Our comments below mirror the comments we submitted to CPSC back in November.

The new report by NIST describes a series of tests performed for CPSC on generators in commercially available and modified low CO emission prototype configurations to determine their CO emission and oxygen consumption rates while operating in a single-zone enclosed space. For two different unmodified commercially available generators (i.e., with carbureted engines lacking CO-emission controls), CO emissions ranged from a low of around 500 grams per hour (g/hr) at near ambient oxygen levels to a high of nearly 4000 g/h as oxygen approached 17%. Tests of two modified, low CO emission prototype generators (i.e., commercially available units adapted with closed-loop electronic fuel injection and a small catalyst integrated into the muffler) showed CO emissions reductions of over 90% with most CO emission rates well below 500 g/hr, and no trend toward higher emission rates was seen as the oxygen level dropped.

Like CPSC's September 2012 test program, the results of the NIST study support the experience of catalyst manufacturers and the recommendations provided by MECA on the effectiveness of the use of catalysts to reduce CO emissions and improve the safety of portable generators. Catalyst technology is a cost-effective technique for substantially reducing CO

exhaust emissions from spark-ignited, gasoline portable generators. Catalyst technology for small gasoline engines like those used in portable generators draws from nearly 40 years of successful experience in the U.S. with catalytic converters applied to light-duty gasoline cars and trucks. Similar catalyst technology has been successfully applied to a wide variety of smaller, two-stroke and four-stroke gasoline engine applications, including handheld equipment (e.g., chainsaws, leaf blowers, string trimmers), non-handheld equipment (e.g., lawn mowers), motor scooters, motorcycles, marine engines, and forklift trucks. In many cases, these catalyst systems have been engineered to provide high reductions of CO emissions as well as reductions in hydrocarbon (HC) and NOx emissions. The U.S. EPA in its small engine test program that was completed in advance of their Phase 3 small engine regulations (published in October 2008) clearly demonstrated that catalysts can be safely incorporated on Class 1 and Class 2 gasoline engines without any significant increase in muffler surface temperatures. MECA and MECA members were active participants in EPA's small gasoline engine test program.

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, CO, NOx) 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^{o}C or higher), and that a reasonable catalyst volume relative to the volumetric flow of exhaust gas is contained in the system. Catalyst formulations can be optimized for these small engine applications to deliver maximum CO reductions and/or NOx reductions depending on the final emissions target. Precious metal costs for these small engine catalysts are typically less than half the total cost of the finished catalyst. The addition of a catalyst to a small engine would have only a very small impact on the cost of a gasoline generator.

The most widely used method for accurate, and cost effective, air/fuel ratio control is through the use of fuel injector technology in combination with a closed-loop control strategy that employs a simple engine control unit (ECU) and an oxygen sensor present in the exhaust, upstream of the catalyst. The sensor provides a feedback loop to the engine's intake air and fuel metering system. The combination of closed-loop, electronic fuel injection with a catalyst reduces engine-out emissions and ensures consistent engine operation. This more stable, reduced engine-out emissions operation reduces the thermal stress on the catalyst and improves the catalyst durability. Such an approach has been applied to a whole range of spark-ignited engines from passenger cars to handheld lawn and garden equipment, and this is the same approach that was effectively demonstrated on the two modified, low CO emission prototype generators in the NIST study, as well as on the small gasoline-powered portable generator in CPSC's previous demonstration program.

MECA is aware of two manufacturers of four-stroke, gasoline generators that are already using properly designed exhaust systems with catalysts to reduce CO emissions by more than 90% compared to uncontrolled levels: Westerbeke Corporation and Kohler Power Systems. Both of these companies have targeted marine applications for these ultra-low CO emission

generators. The same strategy is applicable to portable generators for home use. MECA believes that the ultra-low CO emission generators offered by Westerbeke and Kohler employ the same type of strategy (controlled exhaust air/fuel ratio near the stoichiometric point) to achieve high CO conversion efficiencies across a catalyst as documented in the subject report.

In summary, similar to CPSC's September 2012 test program, the commission has effectively demonstrated in the NIST study that catalyst-based exhaust emission controls are a proven, cost-effective, durable, and safe strategy for reducing CO emissions from small, four-stroke gasoline engines like those used in portable generators. The combination of precious metal-based, three-way catalyst formulations and precise air/fuel control has been shown to provide CO conversion efficiencies well in excess of 90% on a small, four-stroke gasoline engine in a portable home generator. We commend the commission on its ongoing work to demonstrate the effectiveness of state-of-the-art combustion controls in combination with catalyst technologies to reduce CO emissions from these generators. MECA continues to strongly support CPSC's efforts in urging portable generator manufacturers to voluntarily implement these cost effective strategies to reduce CO emissions and improve the safety of home portable generators. In addition, in the absence of a voluntary standard, MECA believes that EPA should strongly consider adoption of a mandatory, low CO emission standard for gasoline generators.

CONTACT:

Joseph Kubsh
Executive Director
Manufacturers of Emission Controls Association
2200 Wilson Boulevard
Suite 310
Arlington, VA 22201
Phone: (202) 296-4797 x107
E-mail: jkubsh@meca.org