Public Comments on CPSC staff report Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator, dated September 14, 2012 (as of January 23, 2013)

PGMA
Portable Generator Manufacturers' Association

Secretary/Treasurer:
THOMAS ASSOCIATES, INC.

November 12, 2012

Ms. Janet L. Buyer
Project Manager
Directorate for Engineering Sciences
U.S. Consumer Product Safety Commission
4330 East West Highway
Bethesda, MD 20814

SUBJECT: PGMA Comments on CPSC Report "Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator"

Dear Ms. Buyer:

The Portable Generator Manufacturers' Association (PGMA) is pleased to offer its comments on the recently released CPSC report entitled "Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator".

PGMA is a trade association that seeks to develop and influence safety and performance standards for our industry's products. As the history of both PGMA and the individual members of PGMA demonstrate, our commitment to safety is sincere and backed by repeated actions. Since our members include the major industry manufacturers of portable generators sold in North America and a significant majority of the industry, we are the recognized voice of the portable generator industry, particularly with respect to safety.

Our member companies include:

- American Honda Motor Company
- Briggs & Stratton Power Products Group
- Champion Power Equipment
- Generac Power Systems
- Pramac America
- Subaru Industrial Power
- Techtronic Industries, North America
- Wacker Neuson Production Americas
- Yamaha Motor Corporation USA

PGMA shares with CPSC the goal of promoting and continuously improving the safe and proper use of portable generators, and we look forward to continuing discussions on this very important topic.

We welcome the CPSC report as a valuable contribution to the many efforts already expended by PGMA, CPSC, and others aimed at achieving this shared goal and congratulate you on the completion of your study. The comments that follow are offered in a spirit of cooperation and we look forward to working with you to make the use of our products even safer.

The CPSC report is based on the premise that reduced CO emission rates from common portable generators "can provide additional critical time for consumers to recognize and escape," and thus reduce the number of CO deaths from portable generators. We did not, however, see any documentation or studies confirming that increasing the time between initial exposure and the onset of critical symptoms will actually lead to more escapes. Given the importance of the premise to the report, PGMA encourages CPSC to provide the study on which the premise is based or to conduct a study to validate it. While the proposition may seem intuitive, it could also be possible that someone experiencing minor symptoms from reduced CO emissions will be even less likely to attribute them to CO than someone exposed to emissions from an unmodified generator. Moreover, decreasing the rate of symptom onset would not benefit someone who is sleeping and could reduce awareness that a serious problem is at hand.

There are, as you are certainly aware, no warning signs commonly and uniquely associated with carbon monoxide poisoning regardless of how quickly the carbon monoxide poisoning occurs or begins to occur. This is because the headache and nausea associated with carbon monoxide poisoning are such common, everyday occurrences for virtually everyone that it is questionable whether those symptoms would be recognized as being caused by carbon monoxide exposure. Empirical data would be extremely valuable, and probably necessary, to support the proposition that a consumer experiencing early reactions to carbon monoxide poisoning would realize the source of the symptoms as carbon monoxide and react in the manner desired, that is to quickly leave the area for a place with fresh, untainted air.

We wholeheartedly agree with the statement in the CPSC's Press Release for the report that recognizes that a carbon monoxide (CO) hazard would continue to exist even if the technology applied to the prototype generator were applied to commercially available generators, and that educating owners about the proper use of their generators will therefore remain the first line of defense:

> "The CPSC continues to urge consumers to never run their portable generators in their attached garages, in or even near their houses, including avoiding placement near windows or vents. Generators should only be used outside, far away from homes. CPSC cautions that even if portable gasoline powered generators were to incorporate this technology, they would still need to be used outside, far from the home. The technology does not make them safe for indoor use." (CPSC Press Release #12-278, September 14, 2012).

For this reason, PGMA encourages CPSC to conduct a study that includes a human factors analysis to determine the effectiveness of the CPSC mandated CO warning adopted in 2007. In any event, PGMA encourages CPSC to revise the mandated warning to incorporate the standards and format in ANSI Z535.3-2011 and Z535.4-2011.

CPSC also recognizes that "[a]nother important line of defense against CO poisoning is having CO alarms on each level of the home and outside sleeping areas. Based on available alarm data, 93 percent of CO-related deaths involving generators take place in homes with no CO alarms. Much like smoke alarms designed to alert consumers about smoke or fires, CO alarms are designed to alert consumers to dangerous CO levels and give them time to get out of the house before becoming incapacitated." (CPSC Press Release #12-278, September 14, 2012). States and local communities throughout the United States have recognized the role CO monitors play in protecting consumers from the multiple sources of CO present in everyday life – furnaces, space heaters, and charcoal grills to name a few. As a result, the number of states adopting mandatory CO monitor laws and codes has increased significantly over the last 5 years. PGMA encourages the adoption of such a requirement in every state as a cost effective means of significantly reducing the CO hazard from multiple sources. CPSC could use its influence to further promote the adoption of statutes, regulations and building codes requiring the use of CO monitors in living spaces as a means of implementing its objective of protecting consumers.

PGMA also encourages CPSC to analyze the data it has collected on CO poisoning and deaths to develop a public awareness campaign that is targeted based on use conditions and user groups, similar to what has been done with hazards such as fires and severe weather. PGMA would support such an effort by CPSC.

With respect to the demonstration project, if the fuel injectors, catalytic converters, electronic sensors, etc., employed on the prototype generator were installed on currently available generators, it would result in significant changes to the product that is on the market today. The study does not, however, identify or address what problems might arise in trying to incorporate such technologies. There are significant differences between the products on which those technologies currently are employed, such as cars and marine generators, and portable gasoline powered generators, as well as significant differences in how the various products are used by consumers. The Commission report cites marine generators as an example to be followed by the portable generator manufacturers, however they are distinctly different products in that marine generators are typically fixed in place on boats, are water cooled with access to large quantities of water to accomplish cooling and are priced between $6,000 to $8,000.

Further, the road from prototype to commercial viability is typically as long and fraught with as many issues as the initial stages of development. Indeed, the CPSC study itself was 5 years in development for a single prototype. It used a commercial grade of engine on the market today installed in an open-frame design that allows for maximum heat dissipation. It is reasonable to conclude that had the staff used a more typical residential model that is on the market today the results would have been different.

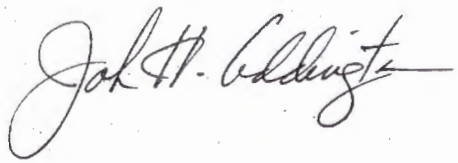
Assuming the practical challenges could be overcome, one would not be surprised to find a significant difference between the cost to manufacture the product on the market today and that to make products that incorporate the technology used with the CPSC prototype

model. If there is a significant difference, the speed with which new product penetrates the market will be adversely affected. A significant cost difference is also likely to result in the increase of repairs to older product and an active used portable generator market, again negatively reducing market penetration of new product. The price difference also raises implementation concerns with the viability of the CPSC's suggested approach of a voluntary standard. The report does not provide an analysis of the market impact of the technology price difference and voluntary standard approach which would be a factor in the success of the strategy set forth by CPSC to reduce CO deaths.

For its part, PGMA continues to develop a portable generator safety standard by means of the canvass process of the American National Standards Institute (ANSI) and to pursue opportunities to raise awareness. As part of the ANSI process, PGMA would welcome the participation and support of CPSC Staff in order to maximize our shared goal of safe use of portable generators. In terms of raising awareness, PGMA is extremely encouraged by its recent discussions with the National Association of Regulatory Utility Commissioners about finding ways to include and standardize the CO message being delivered via the utility industry's various forms of media. Reducing the number of portable generator related CO incidents that occur after a utility company shuts off the power, due to nonpayment for example, shows promise and this effort could be enhanced by the CPSC's participation. We have accepted an invitation from the National Association of Regulatory Utility Commissioners to present at their NARUC meeting in Washington, D.C. on February 3-6, 2013. We invite CPSC representatives to present our safety message with us at the NARUC Washington meeting. We also invite CPSC to work with PGMA collaboratively as other opportunities arise.

Further, as the leading trade association of manufacturers of portable generators, PGMA would be pleased to meet in person with CPSC Staff to discuss the many technological and policy issues implicated by our mutual safety efforts. To attain the most advantageous level of safety, PGMA would be pleased not only to facilitate an in-person meeting of CPSC Staff with PGMA, but also to facilitate meetings of CPSC with individual corporate members of PGMA, so that CPSC Staff will have all relevant information available to it as it considers safe use of portable generators.

Very Truly Yours,



JOHN H. ADDINGTON
Executive Director
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JHA/jlb
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November 13, 2012

VIA E-MAIL

Ms. Janet L. Buyer
Project Manager
U.S. Consumer Product Safety Commission
4330 East West Highway
Bethesda, MD 20814

Re: **CPSC Report "Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator"**

Dear Ms. Buyer:

The Truck and Engine Manufacturers Association (EMA) appreciates the opportunity to provide comments regarding the above-referenced report. EMA is the trade association that represents the world's leading manufacturers of internal combustion engines. The engines manufactured by EMA's members include non-road spark ignition engines used to power portable generators such as those involved in the subject technology demonstration.

EMA's comments and recommendations are based on EMA member company experience designing, certifying, and manufacturing a wide variety of engines that comply with U.S. EPA Phase 3 Regulations including engines utilized in portable generators operating on gasoline, propane, and natural gas.

EMA agrees with the comments submitted by the Portable Generator Manufacturers' Association. In particular, the significant engine design changes required to incorporate electronic control unit (ECU), manifold air pressure sensor (MAP), fuel pump, fuel injector, crank position sensor, toothed timing wheel, modified ignition coil, intake air temperature sensor, oil temperature sensor, exhaust oxygen sensor, catalyst aftertreatment muffler system, battery, and related electrical and mechanical connecting components. Engine designs that incorporate the report's design changes are possible, but may not be suitable for all engines, including many utilized to power portable generators. This is especially true when considering the price point and reliability considerations associated with portable generators designed and sold to consumers for emergency or infrequent use.

EMA is very concerned that the report proposes adoption of a voluntary program, which is likely to result in a significant price point discrepancy between compliant and non-compliant products. A significant number of portable generators are purchased by consumers at the onset

of an emergency situation whereby their normal electrical service is interrupted. In contrast to consumers who recognize a potential for electrical service interruption and therefore install fixed standby power systems, these "emergency purchasers" typically store their units upon resolution of the near term emergency that caused the portable generator to be purchased, typically without conducting any preventative maintenance until the next emergency. Even the simplest engine fuel system designs, which utilize gravity feed carburetors and self contained electrical systems (no battery), experience problems associated with fuel degradation and mechanical/electrical concerns during long-term storage. The added complexity associated with the numerous components associated with the prototype design developed in the technology demonstration project will only exacerbate these concerns.

As noted during the U.S. EPA Phase 3 regulatory development process, the small spark-ignition engine industry is very diverse, and engine designs must be viable for a wide variety of products. Although portable generator engines contain features that are different than typical lawn and garden engines, the vast majority of the engine design, including basic fuel and ignition systems, is uniform across all product lines. This uniformity provides both manufacturing flexibility and economy of scale. To the extent that implementation of the reports proposal would require significantly different engine designs for portable generators, it raises significant concerns that impact both cost and availability.

EMA notes that CPSC has not proposed a voluntary CO standard level beyond the original technology demonstration target of 30 g/kW-hr. EMA does not know the relationship between an engine's CO levels compared to the model home CO levels, but the measured CO levels for the prototype engine were in the 2 g/kW-hr range at zero hours and in the 18 g/kW-hr range at 500 hours. It is unclear if the CO exposure levels measured in the model house would be significantly different for engine out CO emissions of 2, versus 18, versus 30 g/kW-hr. However, it is clear that a deterioration factor for CO of 9 as reflected by the demonstration program prototype would require a new engine out CO level close to 3 g/kW-hr to achieve compliance with a 30 g/kW-hr standard at the end of the 500 hour useful life period.

If CPSC determines that it wishes to pursue development of a voluntary CO standard for portable generators EMA would be very interested in working with it on the details of such a standard. In the interim, EMA is available for meetings and/or teleconferences if CPSC has any questions concerning small spark-ignition engines utilized to power portable generators.

Sincerely,

Roger Gault

Roger Gault
Technical Director

cc: Jed R. Mandel, President

HONDA

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November 13, 2012

Ms. Janet L. Buyer
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SUBJECT: Honda Comments on CPSC Report "Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator"

Dear Ms. Buyer:

American Honda submits the following comments on the recently published CPSC report titled "Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator".

Honda shares in the CPSC's objective to significantly reduce the number of incidents of CO poisoning that result from the misuse of portable generators. To accomplish that, Honda believes that a multi-pronged approach is necessary, one that includes raising consumer awareness through information and education, promoting CO detector use, and exploring technology that can reduce the level of CO that is generated at the source.

In regards to the latter, Honda has been a leader in the development of new engine technologies that have driven improvements in efficiency and the reduction of harmful emissions. Our organization literally has decades of experience in developing low emission engines through the use of fuel injection, exhaust catalyzers, and innovative control systems. We also have a firm understanding of how our products are used and perform in the real world, and we continuously gather and use this information to drive improvements in quality and value for our customers. The foundation that has helped strengthen the Honda brand image beyond, perhaps, all others is the intensive testing and design qualification regimen utilized by our engineering departments. Indeed, the fact that the Honda GX390 engine used in the CPSC research withstood severe operating conditions for which it was not designed and, for the most part, withstood them without catastrophic failure is a testament to our philosophy of building products that exceed our customers' expectations.

While we always enjoy hearing how our products perform under severe conditions such as these and, from that standpoint, would like to call the CPSC test a success, we also have to be realistic about its limitations. Specifically, from Honda's review of Figure 22 of the report, a photograph of the cylinder head from the prototype engine, it appears that combustion gases had been leaking to the outside because the head gasket on the prototype engine was in the early stages of failure prior to the time that the engine was disassembled. This determination is based on the discoloration caused by carbon deposits on the cylinder head fin and the inconsistent appearance on the cylinder head gasket surface compared to the baseline. This failure almost certainly was

the result of increased combustion temperatures created by running the engine at stoichometric air/fuel mixtures, one of the fundamental challenges of applying a stochiometric air/fuel mixture to a stationary air cooled engine.

While the researchers involved in this project may not have appreciated the incipient failure mode, failures such as these are to be expected under such circumstances and typically would be countermeasured by increased cooling. Automobiles, motorcycles, and marine engines (and marine generators), where water cooling or air-water cooling to manage the additional heat is practicable and feasible, are typically able to avoid this type of failure. For portable generators (as well as portable lawn and garden equipment powered by gasoline engines) that are used in a stationary manner, however, neither water cooling nor air-water cooling is feasible (and hence is not applied), and radiant cooling is insufficient to deal the increased heat load of stoichometric combustion.

Another important, and related, point is that the engine in this demonstration only was tested to 500 hours, the declared useful life of the subject engine under EPA phase 2 regulations. However, the comparable engine available today is declared to 1,000 hours useful life under EPA phase 3 and, as such, would be required to demonstrate twice the operating duration without showing any failure like the one noted above. Given that the head gasket already was leaking at 500 hours, complete failure due to the high operating temperatures certainly would have been realized and other component failures would also likely have occurred prior to reaching the 1,000 hour mark. It should go without saying that patterned head gasket failures and patterned failures of other emissions related components are violations of the Clean Air Act and would require product recall and remediation.

Of similar importance is the fact that the engine only was tested using the 6 mode emissions test for a period of 500 hours. This test only tests emissions durability, and is in no way a test for overall product durability and fitness for a particular use, the requirements to which manufacturers are held under the principles of applied warranty. To meet our many obligations under Federal and state laws and regulations, as well as the needs and expectations of our customers, Honda utilizes more severe modes and requirements for product durability. Had the prototype engine been subjected to Honda's full array of durability testing, we are doubtful that there would have been satisfactory results.

Additionally, the CPSC's testing did not evaluate engine and generator performance in transient load conditions, conditions to which portable generators typically are subjected in normal use. Transient in this context means that the mechanical load conditions applied to the gasoline engine vary, often significantly, as electrical loads fluctuate, such as when starting an electric motor that drives a refrigerator or an air compressor. These instantaneous start-up loads affect engine combustion in very dynamic ways, and an air-fuel mix condition richer than stoichiometric combustion is required to manage them to prevent engine hunting and surging. Without such instantaneous air/fuel management, the resultant unstable engine operation will produce variations in voltage and frequency that can permanently damage sensitive electrical equipment and cause unreliable operation of other equipment that leads to owner dissatisfaction.

Finally, in terms of evaluating CO risk exposure from portable generators in confined spaces, it is important to understand that CO concentration in a given space depends not only g/kw-hr but also engine displacement. Smaller displacement engines that produce the same quantity of CO on a g/kw-hr basis as larger displacement engines inherently will take a longer time to raise the CO concentration to the same level as the larger engine. As compared to larger engines, smaller displacement engines may therefore provide a slower onset of CO poisoning that might provide consumers additional escape time, a theory often expressed by CPSC staff. This in turn suggests that, should the Commission elect to go forward with the approach outlined in the technical report, different targets for CO emission reduction may be appropriate based on engine displacement. This distinction has practical importance: Technically (and economically) it is easier to apply fuel injection and a catalyst to larger engines than to smaller engines, where the limited size and space to accommodate these technologies makes the application even more challenging. The GX390 engine used in the CPSC's project is a somewhat larger engine than those typically used on the very popular 1kW to 3kW class of portable generators, and the relatively easier application of fuel injection and catalyst technology perhaps was a reason why this size of engine was selected. To avoid unfairly penalizing smaller engines in this regard, further research should be conducted to better understand the effects of engine displacement on potential risk exposure and reduction.

Again, Honda shares in the CPSC objectives and would like to meet directly with CPSC staff and the University of Alabama research team to further discuss these and other issues as we move forward with our own efforts and research.

Thank you for this opportunity to comment and please feel free to contact me with any questions you may have and to schedule a time when you may be available to meet.

Sincerely,

James Jongkind
Manager, Product Regulations & Safety

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November 7, 2012

SUBJECT: MECA Comments on CPSC's Test Report Titled "Technology Demonstration of a Prototype Low CO Emission Portable Generator"

TO: U.S. Consumer Product Safety Commission
Office of Secretary
Washington, DC 20207-0001
cpsc-os@cpsc.gov

FROM: Dr. Joseph Kubsh, Executive Director, MECA (e-mail: jkubsh@meca.org)

The Manufacturers of Emission Controls Association (MECA) is pleased to provide our comments on the CPSC's summary report demonstrating the performance of a prototype portable generator that emits low levels of CO emissions. 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 non-road vehicles and engines. A number of our members have extensive experience in the development, manufacture, and commercial application of CO emission control technologies for stationary engines, as well as, expertise in applying catalyst technologies to small spark ignited engines less than 25 hp.

We thank the CPSC for this opportunity to review the report and provide our comments. MECA has been engaged in the commission'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. Recent events associated with Hurricane Sandy on the east coast of the U.S. once again point to the potential deadly outcomes of operating gasoline generators that emit high levels of CO without proper ventilation. MECA has previously provided comments 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) and MECA's written comments to CPSC's ANPRM on portable generators (dated February 11, 2007). We commend the commission on its decision to demonstrate the effectiveness of state of the art combustion controls in combination with catalyst technologies to achieve CO reduction of over 90% from common portable gasoline generators. We believe that the demonstration program was well designed, well executed and meticulously documented in this final report. The test method used is sound and consistent with accepted practices in the field. The results of emission measurements on the baseline and modified pre and post-catalyst engines are logical and consistent with published ranges for the

technologies tested. MECA agrees with CPSC that the benefit of a catalyst-based emission control system on generators is not encourage the use of these generators in an enclosed environment, but rather to allow a person experiencing mild CO poisoning the additional time to respond to their symptoms before they become incapacitated.

The conclusions 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 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 (Phase 3 small engine emission 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 (hydrocarbons, 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°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 effectively demonstrated on a small gasoline powered portable generator in CPSC's 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, the commission has effectively demonstrated, documented and concluded in the subject report 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. MECA strongly supports the 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 the absence of a voluntary standard, MECA believes that EPA should strongly consider adoption of a mandatory, low CO emission standard for gasoline generators.

Sincerely,

Joseph Kubsh
Executive Director
Manufacturers of Emission Controls Association (MECA)

cc: Janet Buyer, CPSC

DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service

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November 9, 2012

Office of Secretary
Consumer Product Safety Commission
4330 East-West Highway, Room 502
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Dear Sir or Madam:

We are writing in response to the request for comments on the report entitled. "Technology Demonstration of a Prototype Low CO Emission Portable Generator" dated September 14, 2012. We applaud the Consumer Product Safety Commission's effort to demonstrate the technical feasibility of preventing deaths and poisonings from generator emissions. This is an important technological achievement. The National Institute for Occupational Safety and Health (NIOSH) has been involved in the investigation and prevention of carbon monoxide (CO) poisonings from small gasoline-powered engines for many years. We have continued to work on this problem following the identification of CO poisonings and deaths associated with marine engines and generators since 2000. The hazard associated with the emission of CO from portable generators continues to be a very serious concern for both the general public and U.S. workers. NIOSH remains a partner with the CPSC in working to prevent CO poisonings and deaths through increasing awareness of the hazard and encouraging the development of controls to reduce the risk associated with these products.

In 1993, the NIOSH-sponsored Occupational Health Nurses in Agricultural Communities Surveillance Program identified several cases of CO poisoning related to the use of gasoline-powered pressure washers in Iowa [CDC 1993]. Around that same time other public health agencies across the U.S. were also beginning to document CO poisonings related to the use of small gasoline powered engines. This initial work led to the publication of a joint NIOSH/CDHPE/CPSC/OSHA/EPA Alert entitled, "Preventing Carbon Monoxide Poisoning from Small Gasoline-Powered Engines and Tools." This Alert showed that hazardous CO concentrations can be produced by small gasoline-powered generators within minutes. The need for temporary power following hurricanes, ice storms and other power outage situations coupled with the low cost associated with portable generators have resulted in an increase in the purchase and use of these products. As a result, the CDC and CPSC have documented CO poisonings and increasing numbers of deaths related to the use of these products [CPSC 2006, CDC 2005a, CDC 2005b, CDC 2006].

Generator-related CO poisonings on houseboats have been investigated by NIOSH since 2000. From 1990-2008, over 800 CO poisonings have been identified based on hospital records, press accounts, and other sources, with over 140 of these poisonings resulting in death. Two hundred forty-two of the poisonings occurred on houseboats, with more than 200 of these poisonings attributed to generator exhaust alone [National Case Listing 2008]. Following initial investigations which showed very high concentrations of CO on and around houseboats using gasoline-powered generators, NIOSH has conducted many field studies into the ambient levels of CO on and around houseboats and the effect of engineering controls on reducing those levels.

NIOSH has shown that CO concentrations from gasoline-powered generators on houseboats can reach dangerous concentrations [Earnest et al. 2001a, 2001b, 2002; Dunn et al. 2001b, 2003; Echt et al. 2003; Hall 2000, 2001; Hall et al. 2000; McCammon et al. 2000]. CO measured in the exhaust and near the rear of boats has often exceeded the NIOSH Immediately Dangerous to Life and Health (IDLH) value of 1,200 ppm. These engines/generators routinely emit CO at concentrations well above the IDLH and concentrations exceeding the NIOSH workplace ceiling limit of 200 ppm were measured at a distance of 12 feet from the stern of a boat with only the generator in operation [Hall et al. 2000].

Initially, one of the major obstacles in the safe use of gasoline-powered generators was the absence of emission controls. NIOSH researchers partnered with boat builders and marine engine manufacturers since 2001 to address this hazard. Work in that area has resulted in new low-emission generators and other engine technology which have greatly reduced the risk of CO poisoning in the marine environment. Two major manufacturers of marine power generation systems, Westerbeke and Kohler, have developed low CO emission generators. Our evaluations have shown that the addition of technologies such as catalytic converters and electronic fuel injection to marine generators have helped reduce the emissions of CO by over 99% [Earnest 2006, Garcia 2008]. NIOSH monitored the performance of these systems over extended hours of operation to evaluate the life of these catalysts. This effort resulted in comprehensive EPA regulations that dramatically reduced CO emissions from all new marine engines beginning in 2009.

The development of catalytic converters has proven to be a life-saver in preventing motor vehicle-related CO poisonings. In 1970, Congress enacted the Clean Air Act which established automobile engine emission limits. In 1975, automobile manufacturers began installing catalytic converters on U.S. automobiles to comply. An analysis of the effect of these policies on CO-related mortality showed a drop of over 80% in unintentional vehicle-related CO deaths from 1975-1996 [Mott et al. 2002].

Controlling exposures to occupational hazards is the fundamental method to protect workers. Traditionally, a hierarchy of controls has been applied. Following the hierarchy normally leads to the implementation of inherently safer systems, where the risk of illness

or injury is reduced. Implementing controls at the source using catalytic converters and direct injection engine technology represents a best practice approach for substantially reducing CO emissions. We recognize and support the development and wider use of these controls to prevent CO-related poisonings and deaths.

Sincerely,

G. Scott Earnest

G. Scott Earnest, Ph.D., P.E., C.S.P.
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References

CDC [1993]. Unintentional carbon monoxide poisoning from indoor use of pressure washers--Iowa, January 1992-January 1993. Morbidity and Mortality Weekly Report. MMWR *42*(40):777-779, 785.

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From:	CPSC-OS,
To:	Heggs, Angela; Buyer, Janet
Subject:	FW: Response to report titled, TECHNOLOGY DEMONSTRATION OF A PROTOTYPE LOW CARBON MONOXIDE EMISSION PORTABLE GENERATOR
Date:	Wednesday, November 14, 2012 11:42:56 AM
Attachments:	image001.png

Todd Stevenson
Director, The Secretariat
(Office of the Secretary)
Office of the General Counsel
US Consumer Product Safety Commission
(301) 504-6836, Fax (301) 504-0127

From: Ken Fosaaen [mailto:kfosaaen@kerdea.com]
Sent: Tuesday, November 13, 2012 2:49 PM
To: CPSC-OS,
Subject: Response to report titled, TECHNOLOGY DEMONSTRATION OF A PROTOTYPE LOW CARBON MONOXIDE EMISSION PORTABLE GENERATOR

Unfortunately I only found out about this report late last week, so I have not been able to read it in its entirety. However, below are my comments based upon what I was able to read given my time limitations.

The Executive Summary states, "Staff's goal is not to reduce the CO emission rate to make generators safe to run indoors so that occupants can remain in the exposure without serious health consequences, but rather, to reduce it enough, such that symptom onset is delayed, and the rate of progression of worsening symptoms is significantly reduced." Many engines today are designed to run indoors (Zamboni's, forklifts, floor buffers, etc…), so one can only assume the reason for not pursuing this goal is the cost of such a system. Efforts are underway to greatly reduce the cost of EFI systems for the motor scooter markets, and since these are VERY high volume systems, many companies have had great success in developing low-cost systems. It seems to me that leveraging this low-cost technology could make designing generator systems capable of indoor operation feasible (though I would still recommend discouraging indoor operation).

The reported prototype engine operates as a closed-loop EFI engine operating at a target of lambda = 1; however, narrow-band sensors constantly cycle slightly rich and slightly lean, necessitating the CO generated in the rich segment to be converted to CO_2 in the catalyst. If the catalyst ages significantly or fails, significant amounts of the engine-out CO will flow

through the catalyst unconverted and exit the system. This is dangerous if there is no catalyst monitoring system in this design (see next paragraph). Using a wide-band sensor, one can ensure the engine always operates in the lean region, greatly reducing the possibility of CO exiting the exhaust system. The biggest barrier to this is the cost of automotive wide-band sensors, however, newer technology is about to be introduced which significantly reduces the cost of wide-band sensors (provisional patent filed). Once commercialized, this will make lean control economically feasible.

Some engines currently designed for indoor use, incorporate an exhaust monitoring system to disable an engine if it ever begins to run rich. Some companies have adapted Nernst-based oxygen sensors for this, however, this is dangerous since a failed sensor produces a signal similar to a sensor operating in a lean environment. Kerdea has filed a patent application for a better (and cheaper) safety switch, targeting engine applications designed for indoor use (furnaces, water heaters, forklifts, etc.…). Commercialization of this safety sensor (see photo) is underway.

I also recommend seeking out and leveraging technical advancements in the unmanned vehicle industry (see www.auvsi.org). This industry seeks to maximize the power-train's specific power (power to weight ratio) and fuel efficiency to increase "on station time". Though emissions is a very low priority in this industry, there are many new engine designs that maximize power while operating in the lean condition, and may be ideally suited for portable generators. I sent a potential contact at Wright Patterson AFB to Janet Buyer. Additionally, the military has probably invested some resources to deal with this issue, since they use so many generators in their field of operation. I would investigate their approach to this problem.

Finally, the report is useful in determining the exposure under various hypothetical situations. Generator manufacturers are going to want the CO generation limitations expressed in a simpler, less subjective form that don't require a mocked up garage or building for certification. They will want it expressed as a value based upon the engine operating through an operation scenario, analogous to the FTP-75 drive cycle used for many years to determine emissions from cars. This would be similar to that which was imposed by the EPA on marine generators. Developing a model cycle based upon real world usage, then testing under the conditions described in this report would be the next useful step.

Thank you for the opportunity to comment on this report. I hope my comments are

helpful.

Ken E. Fosaaen – Chief Technical Officer
Kerdea Technologies, Inc.
1800 N. Greene Street, Suite H
Greenville, NC 27834
(252) 916-7433
kfosaaen@kerdea.com
Skype: kefosaaen

From:	CPSC-OS,
To:	Buyer, Janet
Cc:	Heggs, Angela
Subject:	FW: Technology Demonstration of a Prototype Low CO Emission Portable Generator
Date:	Monday, December 03, 2012 9:16:11 AM
Attachments:	image001.png

Todd Stevenson
Director, The Secretariat
(Office of the Secretary)
Office of the General Counsel
US Consumer Product Safety Commission
(301) 504-6836, Fax (301) 504-0127

UNITED STATES OF AMERICA
CONSUMER PRODUCT SAFETY COMMISSION

From: Dippner, Mark [mailto:MDippner@jardensafety.com]
Sent: Friday, November 30, 2012 3:56 PM
To: CPSC-OS,
Subject: Technology Demonstration of a Prototype Low CO Emission Portable Generator

These comments are from Mr. Mike Rabbett...

I see three main problems with fitting a CO sensor to a generator; the exhaust from a generator is going to be at high temperature with a very high moisture content and it is going to be depleted in oxygen. All of these, except perhaps the oxygen depletion, could be mitigated by adding extra hardware to cool a sample of the exhaust gases prior to measurement by an electrochemical or tin oxide sensor. The oxygen depletion is going to significantly affect the behavior of these types of sensor because they are based on the balance between oxidizing and reducing species . If I remember correctly, a correctly operating internal combustion engine has an exhaust content of about 4% (ref 20% for natural air). Oxygen starved combustion, when the production of CO rises significantly, can reduce the oxygen concentration to near zero. From that point of view, an oxygen sensor makes much more sense as an indicator of carbon monoxide generation and I would think that the control unit attached to the generator already has this.

If the CPSC must fit a separate CO sensor, then it is possible that the type of sensor that we use would work (given that a sample of the exhaust could be cooled effectively), but the signal may well be caused by the oxygen reduction rather than by the CO emission. To measure CO properly

under these conditions, what is really needed is an infrared absorption based CO sensor, which would be indifferent to the lack of oxygen or the high water vapour concentration.

Consumer Federation of America

November 13, 2012

Janet Buyer, Project Manager
Directorate for Engineering Sciences
U.S. Consumer Product Safety Commission
4330 East West Highway
Bethesda, MD 20814

Submitted via email: jbuyer@cpsc.gov

Dear Ms. Buyer,

I submit these comments in response to the request for comment concerning the *Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator (Demonstration)*. We appreciate that the *Demonstration*, dated September 2012, is open to public comment.

In February of 2007, in response to the public request for comments and information on the Advanced Notice of Proposed Rulemaking (ANPR) for Portable Generators, CFA submitted comments along with Consumers Union. In those comments, we strongly suggested that the CPSC not rely solely on education and labeling due to the lack of effectiveness of these factors to demonstrably decrease generator-related carbon monoxide poisoning. We appreciate that the *Demonstration* looks beyond these factors to consider an approach that seeks to limit carbon monoxide emissions, however, we urge the CPSC to also consider an approach that would include an automatic shut off on generators when carbon monoxide levels become dangerous. CPSC should consider all available technical solutions that could limit carbon monoxide poisoning.

In our 2007 comments, we stated that we believed that the most effective way to reduce injuries and deaths from carbon monoxide poisoning would be for all manufacturers to equip generators with carbon monoxide detectors that would automatically shut off generators if they detect that carbon monoxide levels have reached dangerous levels. We also stated that at the time, many generators on the market had a similar automatic shut off system designed to turn off the generator when it detected that the oil level was low. In addition, we pointed out that the CPSC, itself, had demonstrated proof-of-concept of CO detection safety systems on portable generators in its own labs.

We stand by those comments and reiterate them. We have been disappointed that CPSC has not proceeded quickly to require carbon monoxide detection and automatic shut-off safety mechanisms on all portable generators. We continue to be disappointed that this solution is not adequately addressed, considered, nor embraced in the *Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator*. This failure to address a significant solution to carbon monoxide poisoning is notable and should be remedied. A substantive

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www.ConsumerFed.org

evaluation of carbon monoxide detection and automatic shut-off safety mechanisms should be included in this document and should be meaningfully considered in future CPSC efforts to address generator-related carbon monoxide poisoning.

We look forward to the CPSC's evaluation and potential inclusion of carbon monoxide detection and automatic shut-off safety mechanisms on all portable generators in its future work to protect consumers from carbon monoxide poisoning due to generators.

Sincerely,

Rachel Weintraub

Rachel Weintraub
Legislative Director and Senior Counsel
Consumer Federation of America

From:	CPSC-OS,
To:	Buyer, Janet
Subject:	FW: "Technology Demonstration of a Prototype Low CO Emission Portable Generator"
Date:	Tuesday, September 25, 2012 9:26:01 AM
Attachments:	2012Sx v COHb.pdf

Todd Stevenson
Director, The Secretariat
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-----Original Message-----
From: Hampson, Neil [mailto:Neil.Hampson@vmmc.org]
Sent: Monday, September 24, 2012 6:24 PM
To: CPSC-OS,
Subject: "Technology Demonstration of a Prototype Low CO Emission Portable Generator"

To Whom It May Concern;

I would like to congratulate the CPSC for focusing on the problem of CO poisoning from gasoline-powered electrical generators and the development of a low emission generator. It would undoubtedly save lives if widely applied. As a recognized national expert in the area of CO poisoning in the US, I have published several papers about the problem of generators and CO poisoning.

However, I have problems with the methodology utilized to develop the conclusions reported. Levels of ambient CO were measured, which is fine. Levels of COHb were then predicted by accepted methods, which is also fine. However, prediction of confusion and incapacitation from COHb levels is not possible. In our paper published earlier this year (Hampson NB, Dunn SL, Members of the UHMS/CDC CO Poisoning Surveillance Group. Symptoms of acute carbon monoxide poisoning do not correlate with the initial carboxyhemoglobin level. Undersea Hyperb Med 2012; (39)2: 657-665.), we clearly demonstrate in over 1,300 patients that symptoms of CO poisoning do not correlate well with COHb levels. We point out in the paper that your first Table 4, while commonly quoted, was derived from an almost identical table in a 1923 Bureau of the Mines publication. As discussed in the manuscript, that table was derived from a 1922 Bureau of Mines publication describing experiments performed by 3 investigators who exposed themselves to CO and recorded the effects. They performed 10 exposures in total, achieving a maximum COHb level of 28%. The source for the remainder of the data in their table is speculative.

I do not believe that it is correct to use COHb levels to calculate egress times from a CO-containing environment. There are no data to support the method. I have attached a copy of our manuscript for your review.

Thank you for the opportunity to comment. I would be happy to discuss this further.

Neil B. Hampson, MD
Emeritus Physician
Virginia Mason Medical Center, Seattle

you will assume the risk of a confidentiality breach. Please do not rely on e-mail communication if you or a family member is injured or is experiencing a sudden change in health status.

If you need emergency attention, call 911.

11/13/06

TO: ~~Janet Buyer, CPSC program manager for portable generators~~ Janet Buyer, Project Manager
Directorate for Engineering Sciences
U.S. Consumer Product Safety Commission
4330 East West Highway
Bethesda, MD 20814
Submitted via email to jbuyer@cpsc.gov

CC: Hal Stratton, Jr., Brownstein Hyatt Farber Schreck
Rachel Weintraub, Consumer Federation of America
Peter Sawchuk, Consumer's Union
Kenneth Frank
Daniel Ryan and Hugo Lopez, Underwriters' Laboratories
Keith Jackson, MariTech Industries
Bill Rice, INTEC Controls

~~CC: Hal Stratton, Jr., Brownstein Hyatt Farber Schreck~~
~~Rachel Weintraub, Consumer Federation of America~~
~~Peter Sawchuk, Consumer's Union~~
~~Kenneth Frank~~
~~Daniel Ryan and Hugo Lopez, Underwriters' Laboratories~~
~~Keith Jackson, MariTech Industries~~
~~Bill Rice, Intec Controls~~

FROM: Albert Donnay, consulting toxicologist, adonnay@jhu.edu
5505 42nd Ave, Hyattsville MD 20781

RE: ~~Public C~~Comments on undated CPSC staff report entitled
"Technology Demonstration of a Prototype
Low Carbon Monoxide Emission Portable Generator" (draft TD)[1]

Thank you for making this report available for public comment.

My last comments to you on the subject of improving portable generator safety were sent in 2007 in response to the Advanced Notice of Proposed Rulemaking (ANPR) CPSC published in the Federal Register on December 12, 2006, in which the Commission said it *"was interested in receiving the following information:*

1. *Any information related to reducing the CO [carbon monoxide] emission rate of engines used on p~~if they have to get a ul and when then need it, apply but NOT 2075 (unless~~*

[1] draft TD = "Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator," Janet Buyer, CPSC Directorate for Engineering Sciences, undated but 2012. Accessed 11/12/12 free at http://www.cpsc.gov/library/foia/foia12/os/portgen.pdf via link to "Research Reports" posted under "Voluntary Standards" at http://www.cpsc.gov/volstd/research/research.html

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~~they incorporate any one of the NIOSH limits or ALL of the UL2034 limits)~~ *portable generators, weatherization of portable generators, or interlocking device concepts."* [2]

Consumers Union, the Consumer Federation of America, Kenneth Frank (an ex-VP of operations for Coleman), and I all separately recommended that CPSC require portable gasoline-powered generators to be fitted by the manufacturer with a CO detector linked to an alarm and automatic cut-off switch. This "CO controller" would warn users and stop the generator as soon as a dangerous level of CO was detected, indoors or out. [3]

Now almost six years—and over 450 generator-related CO deaths later—I still believe this is the best possible solution to prevent CO-related deaths and non-fatal poisonings from portable generators. This is because already available CO controllers, such as those widely used for decades to turn exhaust fans on in commercial parking garages when CO levels exceed 25ppm (and alarm if levels exceed 100ppm) rely solely on proven technology that does not require any input on the part of the operator except to annually test the sensor and replace it when indicated, approximately every 5 year. [4]

Only an automatic CO controller set at such a low threshold can stop a portable generator quickly enough to prevent significant CO poisoning of anyone in the immediate vicinity and also prevent any significant CO contamination from accumulating in any room in which the generator may be running – which will protect anyone going to check on the generator if and when it shuts off for any reason from being poisoned by CO in the vicinity.

Given that CPSC "staff began working on ways to reduce CO emissions from engine-powered equipment, including portable generators, in 2002," including "investigating the feasibility of a gas-sensing interlock mechanism;" and given that then Chairman Stratton instructed the executive director in 2005: "to undertake a thorough review of the status of portable generator safety, … to address, at a minimum, the following issues: (1) Feasibility of safety cut-offs that would shut down a generator before CO reaches unsafe levels;"[5] I expected that the staff would proceed expeditiously to review the public comments it received and complete its report to the Commission.

I expected this "thorough review" would include the results from the testing of any options CPSC evaluated including cut-off devices. And I also, of course, hoped that the Commission—once informed by these results—would proceed quickly to propose engineering controls that could stem the rising tide of CO deaths.

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[2] Portable Generators; Advance Notice of Proposed Rulemaking; Request for Comments and Information, 71 FR 74472.4, 12/12/2006. Accessed free at https://federalregister.gov/a/E6-21131

[3] All comments available at http://www.cpsc.gov/library/foia/foia07/pubcom/portgenanpr.pdf
As indexed by CPSC, ~~Donnay~~ comments ~~= CC 07-3-9,~~ CU & CFA= CC 07-3-10, ~~and~~ Frank ~~=~~ CC 07-3-1, and Donnay= CC 07-3-9

[4] CO controllers for exhaust fans have a more limited range, usually 0-250ppm, and are designed to meet both UL 2017 and section 201.1 of the International Mechanical Code, which requires exhaust fans to come on at 25ppm and alarms at 100ppm. Most ~~and are both more accurate and reliable than home CO alarms. They also~~ can be configured to fail-safe when their battery or sensor need replacing or if other critical components such as alarm circuits fail during automated self-testing.

[5] memo from Commission Chairman Hal Stratton to Executive Director, October 12, 2005, as cited in the 12/12/06 ANPR

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The Commission, however, moved quickly only to upgrade the CO "WARNING" label on portable generators to a pictogram-style "DANGER" label. While label improvements were needed, it is clear from the statistics and case reports compiled since by CPSC that new labels have not stopped CO deaths and poisonings from continuing. Effective engineering controls are clearly still needed.

Given the availability of fail-safe CO controllers, I am appalled that CPSC has allowed the easily resolved problem of CO poisoning caused by portable generators to remain uncorrected for so long. The staff's latest report notes that CO deaths have increased significantly since CPSC began working on this in 2002, with over 650 lives lost in the last decade -- more than CPSC attributes to any other type of combustion appliance it regulates.

When the ANPR was issued in December 2006, its wording suggested that CPSC was open to considering a variety of options for reducing CO deaths and had not yet ruled any in or out of further consideration. The ANPR did not disclose, however, that CPSC staff had already completed their review of CO shut-off switches or that, when presenting their findings to the Commission in October 2006, they had already stated "their belief" "that the most reliable way to limit consumer exposure to harmful CO was to limit the engine's CO emission rate."[6] (My comments on this option follow below.)

Only now six years later, in your draft ~~report concerning portable generators entitled~~ "Technology demonstration of a prototype low carbon monoxide emission portable generator," is this history disclosed.[7] But even this latest report does not fully disclose the extent or results of the staff's testing of shut-off devices, which apparently ended in 2006 before the ANPR was even issued.

The draft TD ~~Your report~~ does not disclose that one CPSC engineer tested and published the results of using a remote CO detector to wirelessly shut down a generator located up to 50' away in August 2006,[8] or that at least one other CPSC engineer tested at least one hard-wired CO controller but never published the results.

In response to my ~~our~~ recent inquiries, you ~~recently~~ claimed that the results from testing the hardwired controller were not publicly available because they were not "cleared" for release.[9] But if so, ~~even if not cleared for release,~~ CPSC ~~staff~~ should still have disclosed to the public that this testing was done, why the results were not cleared for release, and why no further testing was attempted.

If the hardwired results were not cleared pre-2006 due to problems with the quality or integrity of the research or the experimental design, why did you not assign more capable engineers to design and conduct more appropriate tests? But if not cleared due to problems with the hard-wired CO controllers that were tested, why has CPSC not initiated any further investigation of

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[6] Janet Buyer, Staff review of portable generator safety, CPSC Directorate for Engineering Sciences, 10/11/06, Accessed 11/11/12 at http://www.cpsc.gov/library/foia/foia07/brief/PortableGenerators.pdf ~~Staff briefing package to Commission on portable generator safety, October 2006.~~
Also disclosed in draft TD~~latest undated staff report~~, p11.

[7] ~~"Technology demonstration of a prototype low carbon monoxide emission portable generator" Janet Buyer, Project Manager, undated but 2012,~~ draft TD, p10.

[8] "Demonstration of a remote carbon monoxide sensing automatic shut off device" Arthur Lee, Electrical Engineer, August 2006. Accessed 11/12/12 at http://www.cpsc.gov/volstd/engine/COaslpostvet2.pdf

[9] email from Janet Buyer, Project manager, to Albert Donnay, 11/10/12.

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these devices? Hundreds of thousands are already installed in parking garages and other potentially hazardous high CO environments nationwide.

I urge staff to disclose in this latest report exactly what type(s) of hard-wired CO controllers were tested by whom and with what CO alarm points. Staff also should disclose when this option--which you described in the 2006 review as "currently being evaluated by CPSC staff"[10]--was completed, when if and when any staff sought clearance to release the results, and most importantly of course, why clearance (if sought) was refused.[11]

Staff also should include cost estimates for hardwired CO controllers, just as they have published for remote CO controllers in their 2006 review, and they need to consider more than one make or model.

While I was pleased to see that staff provided the Commission with a one-page advertisement for a commercially available CO controller in their 2006 review,[12] ~~same briefing package,~~ the marine model they chose is meant only for use on boats and not appropriate for portable generators. Its CO sensor is not located at the source (in the boat's engine or generator compartment) but in the boat's cabin, and the sensor is nothing more than a standard UL 2034-listed home CO alarm. [13]

As a result, the shut off on this device is not triggered when a specific CO level is exceeded as in commercial CO controllers for garage fans, but only when the one of three time-weighted alarm ranges of UL2034-listed home CO alarms are exceeded.

As CPSC should recognize, it is fatally inappropriate to use home CO alarms as controllers for portable generators that can produce lethal concentrations of CO when used indoors that far exceed the 1200ppm level designated by NIOSH as "immediately dangerous to life and health' – and according to your results, in less than 10 minutes.

The UL2034 standard in contrast, requires alarms to be delayed at least 4 to 15 minutes over 400ppm. and as long as one to four hours (if continuously over 70ppm.[14]

While I agree with the "CPSC staff's preferred approach in addressing any hazard" which is "to attempt to eliminate or reduce the hazard at the source," I strongly disagree with your conclusion that "therefore, the strategy of substantially reducing the engine's CO emission rate

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[10] Janet Buyer, Staff review of portable generator safety. CPSC Directorate for Engineering Sciences, 10/11/06, ~~Janet Buyer. 2006. op cit.~~ p 13.

[11] ~~If the results of testing hardwired CO controllers were not cleared due to problems with the quality or integrity of the research or the experimental design, why did CPSC not simply assign more capable engineers to conduct more appropriate tests? But if not cleared due to problems with the hard-wired CO controllers that were tested, why has CPSC not initiated any further investigation of these devices, since tens of thousands made by over a dozen manufacturers – many with production now based in China - are already installed in parking garages and other high CO environments nationwide?~~

[12] Janet Buyer, Staff review of portable generator safety. CPSC Directorate for Engineering Sciences, 10/11/06, Tab R, page 161. Accessed 11/11/12 at www.cpsc.gov/library/foia/foia07/brief/PortableGenerators.pdf

[13] phone call ~~on 11/12/12~~ with Keith Jackson of Maritech Safety(a division of IPCD Associates), 11/12/12

[14] ANSI/UL 2017 applies to CO controller/central control units and ANSI/UL 2075 applies to linked sensors and transmitters. Details on these and other CO-related device standards were accessed 11/12/12 at www.inteccontrols.com/pdfs/Overview_of_Standards_for_CO_Detection_Products.pdf

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is considered the most appropriate for addressing the CO poisoning hazard associated with this product." [15]

My opinion in this regard is echoed in a survey of fire and rescue personnel in Palm Beach County entitled "An evaluation of the use of portable generators and carbon monoxide poisonings and deaths following hurricanes in Florida." [16] I assume the findings of this 2008 report are known to CPSC and urge that they be acknowledged and referenced in the latest report.

In response to being asked "Which of the following is the most important improvement a generator manufacturer should implement to lower incidents of carbon monoxide poisonings and death?", representatives from 15 of the county's 18 fire and rescue departments voted as follows:

- 1 chose the Commission's priority to "improve signage and warnings";
- 4 chose the staff's priority to "reduce carbon monoxide emissions";

- 16 agreed with our priority, 'detection equipment that shuts the unit down when elevated carbon monoxide levels are detected."

They apparently recognize, as I am concerned CPSC staff do not, that it is far better to automatically shut-off a generator before anyone can be seriously CO poisoned by it than to lower the CO level to which users are exposed but still allow them to be poisoned indefinitely without any warning.

While I support any reasonable effort to reduce CO emissions from any source, CPSC is not an air quality agency, and it should not make this a priority over more effective and less expensive approaches that could actually prevent more—if not all—generator related CO deaths.

The laudable 93% reduction in CO emissions that CPSC achieved in their testing program of an extensively modified generator--including an expensive catalytic converter—did not make generators safe to use indoors even for brief periods.

As shown in the presentation you gave at the GIE+Expo in Louisville last month, CPSC's best prototype still produced sustained CO concentrations of up to 1000ppm in a closed garage, and over 100ppm in a doublewide prefab home to which the garage had been attached by NIST for these experiments.[17] While these levels are less than the NIOSH IDLH level of 1200ppm that you cite for comparison in your report and presentation, the maximum allowed level of acute CO

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[15] draft TD ~~Janet Buyer. TECHNOLOGY DEMONSTRATION OF A PROTOTYPE LOW CARBON MONOXIDE EMISSION PORTABLE GENERATOR, undated,~~ p10:

[16] Gregory Giaccone, February 2008, Delray Beach Fire Rescue. "An applied research project submitted to the National fire Academy as part of the Executive Fire Office Program" Accessed 11/13/12 at http://www.usfa.fema.gov/pdf/efop/efo41768.pdf

[17] Janet Buyer. CPSC Directorate of Engineering Sciences. - "Technology demonstration of a prototype low carbon monoxide emission portable generator" Presentation at GIE+Expo, Louisville KY, October 26, 2012. " Carries disclaimer that "The material contained in this presentation is that of the CPSC staff and has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission." Accessed 11/11/12 at http://www.cpsc.gov/volstd/engine/portgenpres.pdf

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exposure that CPSC should be concerned about is the NIOSH workplace ceiling level of 200ppm, as the staff cited in their October 2006 review.[18]

This is the level at which NIOSH recommendations the immediate evacuation of any workplace, and it is consistent with CPSC's own literature on CO poisoning which warns that "at concentrations above 150 to 200 ppm, disorientation, unconsciousness, and death are possible."[19]

Have CPSC staff noticed that the UL 2034 standards for home CO alarms that it promotes do not allow an instant alarm at the NIOSH ceiling of 200ppm, but instead require a delay of 10 to 50 minutes in this range? Even at twice or more the NIOSH ceiling limit, UL 2034 still requires a delay of at least 4 to 15 minutes. But it is actually the lowest alarm threshold of UL2034—which requires a one to four hour delay if CO is continuously in the 70 to 150ppm range--that allows the greatest inhaled dose of CO over time without any warning, up to 600 ppm*hours (=150x4).
At 600ppm*hours, the maximum CO dose allowed by home CO alarms is almost ~~This~~ more 300% ~~is far more~~ more than the maximum daily inhaled CO dose allowed by US EPA for the public (=216ppm=9x8x3) and 50% more than the 400ppm*hours allowed by US OSHA for healthy workers. ~~BBBBBBBB~~

~~CO alarms like smoke alarms should be required to provide as much—not as little—reliable early warning to consumers as technically possible so that they can stop their poisoning as quickly as possible.~~

~~Post Neurenburg, the Belmont report and the Common Rule, t~~There is no moral justification for UL requiring that consumers be exposed to CO continuously for one to four hours at levels above 70ppm before they can be warned about their CO exposure. CO alarms like smoke alarms should be required to provide as much—not as little—reliable early warning to consumers as technically possible so that they can stop their poisoning as quickly as possible.

It ~~appears~~ is similarly unethical for CPSC to recommend lowering CO emissions from portable generators in order to deliberately prolong and delay the progression of CO poisoning symptoms in the hope that such delays will give otherwise unsuspecting victims more time to recognize the onset of dangerous symptoms.~~!~~

CPSC staff say they do~~es~~ not want to make generators safe for consumers to operate indoors, but this dangerous behavior cannot be stopped by lowering emissions.

Depending on how such CO reductions are promoted by portable generator manufacturers, ~~we~~ I am ~~are~~ concerned ~~that~~ they may create ~~such~~ a false sense of security among consumers and lead more people to try running their generators indoors, which would only increase cases of CO poisoning if not also CO deaths. Consider the automobile analogy: while catalytic converters reduced CO emissions nationwide and so have lowered ambient levels a few ppm per decade, they do not lower emissions enough to prevent CO deaths and poisonings that still

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[18] Janet Buyer. "Staff Review of Portable Generator Safety" 10/11/06, included in ANPR briefing package from staff to Commission, 10/11/06, p17. ~~Accessed 11/11/12 at http://www.cpsc.gov/LIBRARY/FOIA/FOIA07/brief/PortableGenerators.pdf~~

[19] CPSC: Carbon Monoxide Questions and Answers. CPSC Document #466. Accessed 11/12/12 at http://www.cpsc.gov/cpscpub/pubs/466.html

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occur when people leave their vehicles idling inside attached garages.

There is simply no research evidence to support sStaff belief believe that a lower CO emission rate would will reduce CO deaths by first delaying the onset of CO symptoms among poisoning victims and then by slowing the rate of symptom progression from mild to incapacitating so that victims may have more time to recognize their symptoms and also to escape to fresh air.

This approach would not necessarily reduce CO poisonings, however, because the total inhaled dose of CO (which equals the average concentration inhaled multiplied by the time of exposure) could easily be greater than if occupants had been exposed to much higher levels of the generator's CO emissions were much higher, as higher exposure will would provoke symptoms sooner and lead to faster activation of any home CO alarms, whether in the same room as the generator or elsewhere.

The difference in alarm response time between the lowest and highest thresholds is significant: generator users could be warned of a CO danger after as few as 4 minutes at exposures over 400ppm as compared to as long as 4 hours if their exposure stayed above 70 but did not exceed 150ppm for 10-50 minutes.[20] Notably and of great concern is that the home CO alarms CPSC tested in the kitchens kitchen while a generator s ran in garages were never activated, even though the after the generator ran for over an hour. s had been running for an hour or more , but even if located in the garage, a home CO alarm could still take 15 minutes over 400ppm to alarm, at which point aAnyone entering the garage to check on the generator at that point could could be exposed to thousands of ppm and quickly incapacitated or killed.

The staff's stated goals of delaying both the onset of CO symptoms and the rate of their progression from mild to incapacitating are misguided because any delxay in recognizing the problem and stopping further exposure will only needlessly extend the victims' exposure time and worsen their cumulative CO poisoning, without any assurance that they will be sufficiently educated, alert and able to respond as CPSC staff hope by moving promptly to fresh air.

CPSC staff acknowledge that this approach depends entirely on those who are being CO poisoned to:

a) "recognize that their symptoms are indicative of dea developing hazardous situation" and
b) "even if they are not aware of the cause" (likely since CO poisoning usually begins with very common flu-like symptoms), "remove themselves from the exposure before being incapacitated."[21]

But staff have not presented any human data in this report or their 2006 review to support their belief that that consumers with no prior experience of CO poisoning and no CO alarm to warn

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[20] The total inhaled dose from 400ppm of CO exposure for 15min is 100ppm*hours and, so the same as after 4 hours of exposure to 100ppm, but the health effects of low and slow CO exposures are often more serious because lower CO levels are not as aggressively sequestered in blood as COHb, which allows relatively more free CO to diffuse from plasma into tissues., but the higher level of exposure is actually better tolerated because more aggressively sequestered by hemoglobin in blood, allowing relatively less of the total exposure to diffuse from blood into tissue where CO actually causing symptoms through its binding with myoglobin, neuroglobin, cytochromes and other heme proteins that are much more bioactive than hemoglobin.

[21] draft TD, p11.

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them will either recognize their early flu-like CO symptoms as 'dangerous' or know ~~what~~ response is appropriate if they do.~~respond appropriately.~~

Consumers who develop common early warning symptoms of CO poisoning such as headache and fatigue during whatever stressful emergency has led them to use their portable generator are unlikely to think of these as "dangerous" and more likely to simply take an aspirin or a nap than to go outside into fresh air, especially if they are in the midst a storm or other inhospitable weather.

Most critically~~But even if there were data to support this human canary approach~~, it is completely unethical—and thankfully unnecessary—to put the burden of reducing excess CO deaths from portable generators on consumers by expecting them to use their own bodies as CO detectors, ~~especially~~ when fail-safe CO controllers for exhaust fans are available ~~for under $100~~ that activate within 60 seconds above 25ppm and could therefore prevent both CO-related poisonings and deaths. It would be a giant leap backwards for CPSC to ignore this proven ~~if it were to abandon proven~~ technology without at least first giving it a fair ~~and transparent~~ test.

~~While~~ Sstaff have repeatedly raised ~~several~~ concerns dating back to the 2006 review about the durability ~~suitability~~ of attaching ~~integrated~~ CO controllers attached to ~~for use on~~ portable generators—citing the need to protect them ~~including protecting them~~ from extreme weather, heat, and vibration. But ~~—dozens of is no zzzzzz~~those designed

~~shortage of commercially available devices~~for year-round use in parking garages to specifications of the International Mechanical Code and UL 2017 are already able to survive such stresses.[22]

~~But we reject—and~~ They are not, however, designed ~~urge CPSC staff to reconsider—their 2006 assessment that~~
~~"An effective CO alarm should be able to~~ "to discriminate between a small temporary pocket of CO and a potentially lethal cloud~~.~~" as ~~"~~CPSC staff claim "an effective CO alarm should be able to."[23]

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To offer the most possible protection against potentially lethal CO clouds, however, ~~we will always want~~ CPSC should ~~whatever~~ want CO controllers to shut off ~~is attached to a~~ portable generators ~~to alarm~~ whenever their ~~its~~ threshold ~~set point~~ is exceeded, even if outside. ~~, either immediately or after whatever brief length of time medical experts would consider acceptable to ignore as a harmless and fleeting exposure.~~

What staff view as "a disadvantage of this approach" –namely that "the CO sensor may impair the ability of the generator to run when properly operated outdoors if the exhaust accumulates or circulates around the generator" – is in fact one of its advantages because it can ~~can~~ prevent inadvertent CO poisonings from generators set up improperly either indoors or outdoors ~~as well as indoors~~,

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[22] See, for example, CO controller model SPC3-1112 by Intec Controls, which is weatherproof from -14F to 122F, and has a user-replaceable sensor with a 5 year life expectancy as well as a digital display of the current CO level and audio/visual alarm signals. Accessed 11/13/12 at www.inteccontrols.com/pdfs/SPC3-1112.pdf

[23] "Demonstration of a remote carbon monoxide sensing automatic shut off device" Arthur Lee, Electrical Engineer, August 2006. p4. Accessed 11/11/12 at http://www.cpsc.gov/volstd/engine/COaslpostvet2.pdf

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If a CO controller shuts of a generator outdoors, it will most likely be because the generator ~~But a~~ was located ~~CO controller is much more likely to shut off a generator operating improperly outdoors than properly, such as when placed~~ closer than ~~the manufacturer~~ recommended~~s~~ to potential obstructions such as buildings, vehicles, and hedges ~~which~~ that can block the dissipation of exhaust.

Generators should be prevented from running in such conditions, and it should not take too many CO alarms for users to realize they the need to place the generator further from obstructions and/or rotate the frame so that the exhaust stream blows downwind instead of back towards the generator.

The fact that "small pockets of CO may cause the sensor to alarm and shut off the generator even though CO has not entered the home" is not too high a price to pay to protect people who might otherwise be severely poisoned simply by standing outside next to a generator for a few minutes.

~~I~~We urge CPSC to more thoroughly test commercially available CO controllers with 35ppm thresholds for their ability to shut off portable generators both indoors and out —and to warn users–before CO poisoning occurs. These tests should be done with devices listed to UL 2017 and/or UL2075 standards, not UL 2034.[24]

If these tests prove successful, ~~I~~we ~~will~~ urge the Commission to move quickly to require that manufacturers install a CO controller on all new portable generators. Given their proven life-saving potential in other applications, this should be the Commission's highest priority, regardless of any other technological or educational approaches they may consider. The Commission also should ask ~~We would like to see~~ manufacturers voluntarily recall and install effective CO controllers on all previously sold generators, or at least ~~offer to~~ make this upgrade available at cost ~~for~~ out-of-warranty customers who request it.

If generator manufacturers formed a consortium to jointly purchase a mutually agreed upon model of CO controller for the largest possible economy ~~ies~~ of scale, their unit cost would be less than that of currently available hardwired home CO alarms designed to the UL 2034 standard with a digital display and 9v battery backup. ~~I~~We estimate this additional cost to be in the range of $20~~10~~-$4~~2~~0. ~~, but even~~ Even if twice this amount, however, CO controllers are ~~these will be~~ still a far more cost ~~cost~~ effective ~~at~~ method of preventing CO deaths ~~and poisonings~~ than ~~a~~ reducing the rate of CO emissions, which even if successful in preventing some deaths, will only needlessly prolong many more CO poisonings. ~~93% reduction in CO emissions~~

Thank you for your consideration.~~,~~

[24] The SPC3-1112 from Intec Controls meets UL 2075 and 2017 and is made in USA.

Comments on CPSC's Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator

p. ix While the report mentions that the modeling was based on an adult male because most deaths fit this category, you might want to consider also using model inputs for small children and the elderly since they tend to be most vulnerable to the effects of CO, e.g., children's breathing rate is faster.

p. 21 Double check the floor area values for the home and garage. The report lists the house floor area as 140 m^2 (1500 ft^2) and the garage floor area as 105 m^2 (1130 ft^2). The garage seems very large in comparison to the house when you compare the aerial view in Figure 8 and the floor plan in Figure 9 with the measurements listed on p. 21.

p. 24 It looks like having the exhaust pipe pointing toward the house wall is for a worst-case scenario, but it seems like you should also test what happens when the exhaust pipe is pointing away from the house wall because it could still generate enough CO to affect people's health.

From: Parent, Stephanie@ARB
To: Buyer, Janet
Cc: Jenkins, Peggy@ARB
Subject: Unofficial Comments re: the CPSC staff report
Date: Wednesday, November 14, 2012 4:38:31 PM
Attachments: Comments on CPSC Prototype Low-CO Generator.pdf

Hi Janet,

Thank you for the opportunity to comment on CPSC's staff report, "Technology Demonstration of a Prototype Low CO Emission Portable Generator." Attached are informal and unofficial comments. My apologies that they are a day late.

Overall I felt the report was good as well as the idea to research how to develop a low CO emission portable generator.

Please let me know if you have any questions about my comments.

Sincerely,
Stephanie

California Environmental Protection Agency
Air Resources Board

Stephanie Parent
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From: Buyer, Janet [mailto:JBuyer@cpsc.gov]
Sent: Monday, October 29, 2012 5:49 AM
Subject: CPSC presentation summarizing staff report on Technology Demonstration of the Prototype Low CO Emission Portable Generator

Hello all,

Attached is a copy of a presentation I gave at a workshop last week that gives a "reader's

digest" summary of the CPSC staff report " *Technology Demonstration of a Prototype Low CO Emission Portable Generator*" that was recently released (see e-mail below). I am forwarding it around as a way of encouraging folks to send us your comments on the report. I'd be happy to walk anyone through it – I could do it in about 10-15 minutes. The comments we receive will help CPSC forge the path forward. Comments are due to cpsc-os@cpsc.gov by Nov 13. Feel free to forward this to anyone you think should or would be interested.

Regards,
Janet Buyer

Project Manager, Portable Generators
U.S. Consumer Product Safety Commission
Directorate for Engineering Sciences
5 Research Place
Rockville, MD 20850
301-987-2293

From: Buyer, Janet
Sent: Friday, September 14, 2012 12:42 PM
Subject: CPSC releases staff report on staff's technology demonstration of a prototype low CO emission portable generator

I am pleased to inform you that the U.S. Consumer Product Safety Commission (CPSC) has released a report on staff's technology demonstration of a prototype low carbon monoxide (CO) emission portable generator. This staff report, available on-line at http://www.cpsc.gov/library/foia/foia12/os/portgen.pdf, fully documents staff's research performed under the agency's advance notice of proposed rulemaking (ANPR) to address the CO poisoning hazard associated with portable generators. CPSC's press release announcing the report is included below. Staff welcomes your comments on the report; please submit them by e-mail to CPSC's Office of Secretary, cpsc-os@cpsc.gov by November 13, 2012. If you are unable to submit comments by e-mail, you may submit written comments to:

Office of Secretary
U.S. Consumer Product Safety Commission
Washington, DC 20207-0001

Please include the report title "Technology Demonstration of a Prototype Low CO Emission Portable Generator" in your correspondence.

Regards,

Janet Buyer

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For Immediate Release
September 14, 2012
7908
Release #12-278

CPSC Hotline: (800) 638-2772
CPSC Media Contact: (301) 504-

Escaping the Invisible Killer: New CPSC Research Demonstrates Technology That Can Significantly Reduce Poisonous Carbon Monoxide from a Generator

Consumers' escape time increased from eight minutes to 96 minutes

WASHINGTON, D.C. – A new study released today by the U.S. Consumer Product Safety Commission (CPSC) demonstrates that readily available technology can dramatically reduce deadly carbon monoxide (CO) emission rates from certain common portable gasoline-powered generators. The technology can provide additional critical time for consumers to recognize and escape from the deadly hazard of carbon monoxide poisoning. With the adaptation of existing emission control technology, CO rates can be lowered to levels that would save lives. On average, carbon monoxide from portable gasoline-powered generators kills more than 70 people every year.

CPSC staff's study outlined one method to reduce the generator engine's CO emission rate by using closed-loop electronic fuel injection and a small catalyst—the same emission control technology used on motor scooters and small motorcycles. This significantly increased the predicted escape time by twelve times the current time—from eight minutes to 96 minutes—for the deadly scenario when a consumer is in their garage while they are running their generator there.

CPSC's study also showed that the predicted escape time for those consumers inside the house, as opposed to the garage, was even greater. The escape time is the time between onset of obvious symptoms and incapacitation.

The CPSC continues to urge consumers to never run their portable generators in their attached garages, in or even near their houses, including avoiding placement outside near windows or vents. Generators should only be used outside, far away from homes. CPSC cautions that even if portable gasoline-powered generators were to incorporate this technology, they would still need to be used outside, far from the home. The technology does not make them safe for indoor use.

Another important line of defense against CO poisoning is having CO alarms on each level of the home and outside sleeping areas. Based on available alarm data 93

percent of CO-related deaths involving generators take place in homes with no CO alarms. Much like smoke alarms are designed to alert consumers about smoke or fires, CO alarms are designed to alert consumers to dangerous CO levels and give them time to get out of the house before becoming incapacitated.

Deaths involving portable generators have been on the rise since 1999 when generators became widely available to consumers. There have been at least 755 CO deaths involving generators from 1999 through 2011. While reporting of incidents for 2011 is ongoing, there were at least 73 CO related deaths involving generators last year.

Generators are responsible for the largest number of estimated non-fire CO deaths associated with consumer products. From 2006 through 2008, generators accounted for 43 percent of CO deaths compared to 33 percent for heating systems, such as furnaces. Furnaces had historically been responsible for the most CO deaths.

Generators are used by consumers to keep lights, electrical appliances or heating and cooling units running in their homes during power outages. Incapacitation or death can occur within minutes if consumers use a generator inside a home, garage, shed or use it outside near windows or vents, because dangerous levels of CO from a generator's fuel-burning engine build up quickly.

With the release of this study, CPSC is urging manufacturers to voluntarily adopt a stringent CO emission standard for engines used in portable gasoline-powered generators with the expectation that it will improve safety and save lives, just as the marine industry did in 2005. That year, manufacturers of small marine generator engines, voluntarily adopted a stringent CO emission standard to address the hazard of acute poisoning that was causing fatal and serious injuries to boaters exposed to marine generator engine exhaust.

For this study, CPSC worked with the National Institute of Standards and Technology (NIST) and the University of Alabama to develop and test the portable gasoline-powered generators.

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November 13, 2012

Janet Buyer, Project Manager
Directorate for Engineering Sciences
U.S. Consumer Product Safety Commission
4330 East West Hwy, Room 611
Bethesda, MD 20814

Re: 'Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator'

Dear Ms. Buyer,

I have read CPSC's report titled 'Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator.' I am very familiar with the approaches used to demonstrate CO reduction in spark-ignited engines. I am not familiar with the NIST protocols used in the 'test house', nor their airflow simulation programs. I am not familiar with the physiological effects of CO poisoning.

Comments:

- Scientifically and empirically sound report
- Carbon monoxide reduction approach consistent with current emission reduction technologies
- Carbon monoxide reduction efficiency was consistent with the adopted engine control strategy and aftertreatment
- Test procedures for engine emission testing consistent with current practice
- Triplicate tests of the engines is appropriate as these engines' emissions can fluctuate
- CPSC's conclusions regarding engine emissions are consistent with this report's data
- CPSC's conclusion regarding increased 'opportunity' for home occupants to 'recognize and react appropriately to a developing CO exposure' are consistent with this report's data
- Cost of implementation of the engine's CO reduction approach and aftertreatment is not projected
- No reported repeat tests conducted in the NIST 'test house'

Thank you for the opportunity to review your work. It is a well done project and I commend your tenacity in following through over such a long period.

Best Regards,

James N. Carroll
Principal Engineer
Dept. of Engine Design and Development
Engine, Emissions and Vehicle Research Division