



U.S. CONSUMER PRODUCT SAFETY COMMISSION
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Ms. Diana Pappas Jordan
Chair of STP 2201
Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook, IL 60062

RE: CPSC Staff Request for Formation of a Working Group and Staff's Recommendations for Requirements to Address the Carbon Monoxide Poisoning Hazard Associated with Portable Generators

Dear Ms. Jordan:

U.S. Consumer Product Safety Commission (CPSC, Commission) staff requests that Underwriters Laboratories Inc. (UL) form a working group to develop specific proposals for requirements for portable engine-generator sets that fall under the scope of UL 2201, *Portable Engine-Generator Assemblies* to reduce the risk of death and injury due to carbon monoxide (CO) poisoning.^a Since first joining the Standards Technical Panel (STP) for UL 2201 in 2002, CPSC staff has advocated that the STP adopt requirements in the standard to address the rising number of generator-related CO poisoning fatalities. Over the last few years, as part of the agency's rulemaking project to address this hazard,^b CPSC staff has worked to demonstrate the feasibility of lowering engine CO emission rates. The results of this technical work conducted by and for the CPSC provide the solid foundation for staff's rationale and recommendations summarized herein for a framework of performance requirements and corresponding test methods that a working group can use as a starting point to develop specific proposals for consideration by the STP.

Modifying UL 2201 to include CO emission rate limits would address the source of the hazard and make a direct impact on reducing the risk of CO poisoning death and injury associated with the use of portable generators.^c Despite sustained information and education efforts by the CPSC and many other stakeholders to promote public awareness of the generator-related CO hazard, especially before

^a These comments are those of CPSC staff, and they have not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

^b *Portable Generators; Advance Notice of Proposed Rulemaking; Request for Comments and Information*, Federal Register, 71 FR 74472, December 12, 2006. CPSC staff is in the process of developing a draft notice of proposed rulemaking for the Commission's consideration.

^c Examples of reducing engine exhaust CO emission rates as the means to reduce CO deaths and injuries include forklifts and other equipment used in enclosed areas as well as the engines that power marine generators. Furthermore, when catalytic converters were put on automobile engines beginning in 1975 to meet EPA emission standards, it resulted in a reduction of unintentional vehicle-related CO deaths of greater than 80% in the years of 1975 through 1996 compared to earlier years.¹ (Superscripted numbers refer to references listed at the end of this letter.)

and after major storms, the death toll continues to rise. The increase in fatalities has continued even since 2007, when CPSC mandated a hazard label.² According to the CPSC's data, for the 14-year period from 1999 through 2012, there have been at least 800 consumer generator-related CO poisoning fatalities.^{d,3} In addition, in CPSC staff's most recent report on non-fire CO deaths associated with use of consumer products, which provides annual estimates through 2009, generators have overtaken the entire product category of heating systems (including furnaces, portable heaters, and space heaters) to become the consumer product responsible for the largest estimated number of annual non-fire-related CO deaths since 2005.⁴

CPSC staff recommends a single performance requirement and corresponding test method that sets a limit on the engine's exhaust CO emission rate to a level that is technically achievable and will modify the consequent CO exposure profiles to delay progression of CO poisoning symptoms compared to existing generators when operated in an enclosed space.^e This will give exposed occupants more time to recognize that a hazardous situation is developing. This, in turn, will allow occupants greater opportunity to leave the exposure or to take actions that could result in their rescue before becoming incapacitated. To assist in the development of a basis for this requirement, CPSC engaged the National Institute of Standards and Technology (NIST) to perform tests on an unmodified, carbureted 5 kilowatt (kW) generator operating in the attached garage of a single-family home to measure the accumulation of CO in the garage and transport throughout the house. Using the closed garage test data (a common fatal scenario), CPSC staff performed health effects modeling on the ensuing CO exposures, which predicts that occupants in the house and garage would have little time to perceive CO poisoning symptoms before the extremely quick onset of incapacitation and ultimately death.⁵ Consequently, for this requirement, CPSC staff is currently considering an exhaust CO emission rate limit in the range of 100 to 150 grams per hour (g/hr) as the oxygen (O₂) level in the intake air drops below ambient (20.9%). Oxygen depletion occurs when a generator is operated in an enclosed space and this can be an important factor in engine CO production.

Staff's analysis to determine the appropriate limit to recommend is ongoing; however, staff notes that staff's prototype reduced-CO emission 5 kW portable generator emitted CO nominally at, or below 100 g/hr, and no trend toward higher emission rates was seen as the oxygen level dropped.^{5,7} This reduced CO emission rate was accomplished by retrofitting a closed-loop electronic fuel injection system, an O₂ sensor, and a catalyst onto the carbureted 5 kW generator. In contrast, NIST's tests showed that the carbureted unit emitted CO at rates from a low of nominally 500 g/hr near ambient O₂, to a high of nearly 4,000 g/hr as O₂ decreased to 17 percent. Using data from when NIST tested the prototype in the same attached closed garage scenario, CPSC staff's health effects modeling predicts that the garage occupant would experience a twelve-fold delay in progression of CO poisoning symptoms compared to the carbureted unit (96 minutes instead of 8 minutes for the time interval between predicted obvious symptom onset and incapacitation).

While CPSC staff is working with NIST in performing analyses to refine the details of possible requirements, staff offers the following general description of recommendations for a test procedure to determine the generator CO emission rate as the intake O₂ level drops:

After situating the generator in a test chamber with air in the chamber initially set at approximately 68°F, 40% relative humidity, and ambient CO concentrations, start the generator

^d This count is based on 597 incidents entered into CPSC's databases as of April 23, 2013.

^e When the incident location was identified in CPSC's investigation report of an incident, more than 95 percent of the incidents occurred when the generator was operated in an enclosed space.

and apply a continuous resistive load to one of the generator's receptacles. Operate the generator for at least 30 minutes and continue until either the chamber O₂ drops to 16%, or the chamber O₂ reaches steady state above 16% while the generator's delivered power decreases to no more than 60% of the output measured at the beginning of the test. While the generator is operating, record the chamber CO and O₂ concentrations and the generator output power at least once per minute. Using the CO concentration data, the chamber's air change rate, and the chamber volume, calculate the CO emission rate for each 5 minute interval with the load applied. Perform this test with each of the following three loads applied: the maximum load the generator will sustain without tripping its circuit breaker (this is defined as full load), 50% of full load, and 25% of full load. To successfully meet the performance requirement, the CO emission rates at all three loads, calculated as the O₂ drops, must not exceed the emission limit, for which staff is currently considering a value in the range of 100 to 150 g/hr. The chamber volume and its range of achievable air change rates should be sized by the manufacturer according to the engine's O₂ consumption rates while operating under 25% load and full load for the size range of generators they expect to test.

It is possible that an exception to this performance requirement could be made to accommodate alternative approaches suggested in public comments on the staff's technical report on the prototype generator.⁶ Some commenters opined that a shutoff system, particularly one using a CO sensor, should be used as the means to reduce deaths and injuries (*i.e.*, one that would shut off the engine before it creates an unsafe CO exposure).^f It is important to note that although staff investigated four different approaches for a shutoff system, including two that used CO sensors, staff was not able to demonstrate fully how a shutoff system could be implemented satisfactorily.

Accordingly, the working group should consider whether a generator equipped with an automated engine shutoff may be permitted to exceed the CO emission rate limit that staff is currently considering (in the range of 100 to 150 g/hr) when the O₂ is **below** ambient O₂ if all of the following three conditions are met:

1. *The exhaust CO emission rate does not exceed the rate limit of 300 g/hr **at** ambient O₂ (20.9%) when full, 50%, and 25% loads, as defined above, are applied to the generator. This is expected to address the outdoor use scenario where not all of the exhaust from a generator operating outdoors at normal ambient O₂ enters the building to create the occupants' CO exposure profiles. This requirement is intended to provide those consumers who explicitly try to follow manufacturers' instructions with the same increased time interval to recognize a hazardous situation is developing and, correspondingly, the same increased opportunity for escape as those who use the generator in an enclosed space.^g Staff's analysis of the appropriate*

^f It is worth noting that the approach of a CO-sensing shutoff system was considered for a while by some stakeholders as a possible means to address CO deaths and injuries that were occurring on and around recreational boats due to the marine generator engine's exhaust. Because the engine is fixed in the boat, and the locations where the exhaust can infiltrate are known, this seemed to be a straightforward solution; however, all the primary stakeholders, including the National Institute for Occupational Safety and Health (NIOSH), the U.S. Coast Guard (USCG), the U.S. Environmental Protection Agency (EPA), engine manufacturers, and the boating industry, agreed that "one of the best approaches to CO control would be to reduce it at the source."⁹ These stakeholders rejected use of a CO-sensing shutoff system to address the hazard, citing that "Houseboats and other cabin boats are generally fitted with CO detectors . . . often when the CO detectors do alarm, users tend to believe that they are malfunctioning because they do not smell gas. In the case where the alarm goes off frequently, the user may just disconnect the CO detector, even if it has been operating correctly."⁹ As a result, the engine manufacturers voluntarily developed low CO emission engines rather than using a shutoff system.

^g Some manufacturers recommend, or sell with the generator, extension cords 15 or 20 feet long. Almost all manufacturers also recommend that generators be placed under cover when it is wet outside because, although these products are intended

limit is ongoing; however, at this time, 300 g/hr is staff's recommendation for this requirement. Staff is refining the details for a test method that uses a constant-volume sampling (CVS) or raw exhaust emission measurement system to determine the generator's emission rate with each of the three loads applied to the generator at ambient O₂.

2. *When operated in a test chamber, the generator shuts off before the engine emits approximately 25 grams of CO.* This is expected to protect the occupants who take no protective action and **remain** in the consequent CO exposure profiles against serious or lasting adverse health effects when the generator is operated in an enclosed space.⁸ Although staff's analysis of this is ongoing, staff is not currently considering recommending a limit lower than this. The corresponding test method to verify the amount of CO emitted could be performed in a chamber (not necessarily the one described above) and the amount of CO would be calculated from the air change rate, chamber volume, and analysis of the CO concentration data. What must be defined further for this test method, however, are the environmental conditions that should be set for the chamber test and the state of conditioning the shutoff system on the generator should be in when tested. The shutoff system must be durable and work throughout the generator's operational life, without calibration or service, so designs must consider the wide variety of environments in which consumers use their generators and store them during prolonged non-use periods.

Depending on the technology employed for the shutoff system, both the usage and storage environments can pose significant challenges to the durability and reliability of the sensor and control components. For instance, between uses a consumer may store a generator for years in a garage, exposing the shutoff system to extreme temperatures and humidity as well as a multitude of contaminants (e.g. vapors and particulates) that could contaminate a sensor. Further, when the generator is in use, the shutoff system will be exposed to the engine's exhaust, heat, and vibration as well as the extreme winter and summer ambient conditions which cause power outages that motivate consumers to use generators. It is important to note that CO sensors used in residential CO alarms are not designed for use in such extreme environments and CO sensors that may be more durable and used in commercial or industrial settings require periodic professional maintenance and calibration. The test method used to verify a shutoff's performance must account for these and other conditions that the shutoff

for outdoor use only, they are not weatherized for safe use in wet conditions where they can present a risk of shock or electrocution. Staff believes these recommendations can put the consumer at serious risk of exposure to the CO hazard because the recommendations may encourage generator operation in close proximity to a residence or an enclosed environment. During extended power outages in particular, homeowners experience a sense of urgency for basic needs, such as heat and food refrigeration; yet the power cord on many home appliances commonly is not long enough to reach windows or other openings where the consumer could connect the appliance to a 15- or 20-foot extension cord and be able at the same time to locate the generator far away from the opening. Although only a limited number of deaths in CPSC databases are attributed to exhaust entering the house from outdoor generator use, it is important to note that CPSC does not count or estimate CO injuries, but the CPSC databases do have records of such injuries. There are other published sources that show injuries from outdoor operation as well, and a number of these sources document that the injured consumers used their generators an average of only a few feet away from the nearest door or window. In 2013, the Centers for Disease Control and Prevention (CDC) began recommending that generators should never be placed less than 20 feet from an open window, door, or vent where exhaust can vent into an enclosed area. This recommendation is based on results of modeling studies performed by NIST on the effects of operating an existing, carbureted generator outdoors on indoor CO concentration profiles.

To put the CO emission rate of an existing generator into perspective relative to a car, the unmodified carbureted 5 kW portable generator, when operating at ambient O₂ (20.9%), has a CO emission rate that is over **200 times more** than that of an idling 1996 Oldsmobile Cutlass.¹⁰ That factor increases to more than **1,500 times greater** when the generator is operating in an enclosed space.

system is likely to be subjected to over the life of the generator. Staff suggests that the working group define the conditions that are representative of the cumulative effect of these environments so that the shutoff system is subjected to them prior to testing. Staff also suggests that the working group define the characteristics of the chamber that will be used to test it.

3. *The shutoff system is automated, tamper-resistant to deter users from disabling its function, resistant to causing nuisance shutoffs (i.e. causing the generator to shutoff when operated outdoors), and include a supervisory circuit for the control circuit, (i.e., preventing the generator from being able to start if it, or its sensor, were to fail or otherwise not be able to shut off the generator in scenarios that would create an unsafe exposure).* This requirement would be necessary to provide protection under circumstances such as when a system's sensor fails due to contamination or other factors, a system that requires power to operate has a discharged battery or unavailable power source, or the consumer has overridden the circuitry to prevent the system from shutting off the generator. This latter situation might occur with a shutoff system that shuts the generator off when operated in an enclosed space before the occupant experiences any CO poisoning symptoms or when located outdoors in a proper location. Either of these may frustrate the consumer, who might then attempt to bypass its circuitry to prevent it from shutting off the generator. If the generator is later used in an enclosed space, it will fail to provide any protection. Since an appropriate test for this performance requirement is likely to be very specific to the technology used in the system, staff does not have a suggested test method to verify that this performance requirement has been met. Staff suggests that the working group define the test method(s) that are most appropriate.

In closing, CPSC staff reiterates the request for formation of a working group to develop specific proposals, beginning with staff's recommendations discussed in this letter, for consideration by the STP to address the serious CO hazard posed by portable generators. These recommendations will reduce the number of CO poisoning deaths and injuries that result from generator use in enclosed spaces and outdoor locations where the exhaust can infiltrate into enclosed spaces.

Thank you for the opportunity to work with UL and the STP on this very important consumer safety issue. I look forward to continuing to work with the STP to improve the safety of portable generators.

Sincerely,



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cc: Joseph Harding, Technical Director, PGMA
Colin Church, CPSC Voluntary Standards Coordinator
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