CONSUMER PRODUCT SAFETY COMMISSION

16 CFR Part 1241

[Docket No. CPSC–2006–0057]

RIN 3041–AC36

Safety Standard for Portable Generators

AGENCY: Consumer Product Safety Commission.

ACTION: Notice of proposed rulemaking.

SUMMARY: The U.S. Consumer Product Safety Commission has determined preliminarily that there may be an unreasonable risk of injury and death associated with portable generators. To address this risk, the Commission proposes a rule that limits CO emissions from operating portable generators. Specifically, the proposed rule would require that portable generators powered by handheld spark-ignition (SI) engines and Class I SI engines not exceed a weighted CO emission rate of 75 grams per hour (g/hr); generators powered by one-cylinder, Class II SI engines must not exceed a weighted CO emission rate of 150 g/h; and generators powered by Class II SI engines with two cylinders must not exceed a weighted emission rate of 300 g/h.

DATES: Submit comments by February 6, 2017.

ADDRESSES: You may submit comments, identified by Docket No. CPSC–2006–0057, by any of the following methods:

Electronic Submissions: Submit electronic comments to the Federal eRulemaking Portal at: *http://www.regulations.gov.* Follow the instructions for submitting comments. The Commission does not accept comments submitted by electronic mail (email), except through *www.regulations.gov.* The Commission encourages you to submit electronic comments by using the Federal eRulemaking Portal, as described above.

Written Submissions: Submit written submissions by mail/hand delivery/courier to: Office of the Secretary, Consumer Product Safety Commission, Room 820, 4330 East West Highway, Bethesda, MD 20814; telephone (301) 504–7923.

Instructions: All submissions received must include the agency name and docket number for this notice. All comments received may be posted without change, including any personal identifiers, contact information, or other personal information provided, to: *http://www.regulations.gov.* Do not submit confidential business information, trade secret information, or other sensitive or protected information that you do not want to be available to the public. If furnished at all, such information should be submitted in writing.

Docket: For access to the docket to read background documents or comments received, go to: *http://www.regulations.gov,* and insert the docket number CPSC–2006–0057, into the ''Search'' box, and follow the prompts.

FOR FURTHER INFORMATION CONTACT:
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SUPPLEMENTARY INFORMATION:

I. Background

A portable generator is an engine-driven machine that converts chemical energy from the fuel powering the engine into rotational energy, which, in turn, is converted to electrical power. Reports of portable generator-related fatalities and injuries prompted the U.S. Consumer Product Safety Commission (Commission or CPSC) to publish an advance notice of proposed rulemaking (ANPR) in December 2006 to consider whether there may be an unreasonable risk of injury and death associated with portable generators (71 FR 74472 (December 12, 2006)). The ANPR began a rulemaking proceeding under the Consumer Product Safety Act (CPSA). The Commission received 10 comments in response to the ANPR. Subsequently, in a two-part technology demonstration program, CPSC contracted with the University of Alabama (UA) to conduct a low CO emission prototype generator technology development and durability demonstration and contracted with NIST to conduct comparative testing of an unmodified carbureted generator and prototype generators in an attached garage of a test house facility. CPSC staff published a report regarding the results of the UA technology demonstration and received 12 comments in response to this report. NIST published a report concerning its comparative testing of generators and received four comments in response to its report. The Commission is now issuing a notice of proposed rulemaking (NPR) that would establish requirements for carbon monoxide emission rates.[1] The information discussed in this preamble is derived from CPSC staff's briefing package for the NPR, which is available on CPSC's Web site at: *https://www.cpsc.gov/s3fs-public/ProposedRuleSafetyStandardforPortableGenerators.pdf.*

II. Statutory Authority

Portable generators are ''consumer products'' that can be regulated by the Commission under the authority of the CPSA. *See* 15 U.S.C. 2052(a). Section 7 of the CPSA authorizes the Commission to promulgate a mandatory consumer product safety standard that sets forth certain performance requirements for a consumer product or that sets forth certain requirements that a product be marked or accompanied by clear and adequate warnings or instructions. A performance, warning, or instruction standard must be reasonably necessary to prevent or reduce an unreasonable risk or injury. *Id.*

Section 9 of the CPSA specifies the procedure that the Commission must follow to issue a consumer product safety standard under section 7. In accordance with section 9, the Commission may commence rulemaking by issuing an ANPR; as noted previously, the Commission issued an ANPR on portable generators in December 2006. (71 FR 74472 (December 12, 2006)). Section 9 authorizes the Commission to issue an NPR including the proposed rule and a preliminary regulatory analysis, in accordance with section 9(c) of the CPSA and request comments regarding the risk of injury identified by the Commission, the regulatory alternatives being considered, and other possible alternatives for addressing the risk. *Id.* 2058(c). Next, the Commission will consider the comments received in response to the proposed rule and decide whether to issue a final rule, along with a final regulatory analysis. *Id.* 2058(c)–(f). The Commission also will provide an opportunity for interested persons to make oral presentations of the data, views, or arguments, in accordance with section 9(d)(2) of the CPSA. *Id.* 2058(d)(2).

According to section 9(f)(1) of the CPSA, before promulgating a consumer product safety rule, the Commission must consider, and make appropriate findings to be included in the rule, on the following issues:

- The degree and nature of the risk of injury that the rule is designed to eliminate or reduce;
- the approximate number of consumer products subject to the rule;
- the need of the public for the products subject to the rule and the

[1] The Commission voted (4–1) to publish this notice in the **Federal Register**. Chairman Elliot F. Kaye and Commissioners Robert S. Adler, Joseph P. Mohorovic, and Marietta S. Robinson voted to approve publication of the proposed rule. Commissioner Ann Marie Buerkle voted against publication of the proposed rule.

probable effect the rule will have on utility, cost, or availability of such products; and

• the means to achieve the objective of the rule while minimizing adverse effects on competition, manufacturing, and commercial practices.

Id. 2058(f)(1). Under section 9(f)(3) of the CPSA, to issue a final rule, the Commission must find that the rule is ''reasonably necessary to eliminate or reduce an unreasonable risk of injury associated with such product'' and that issuing the rule is in the public interest. *Id.* 2058(f)(3)(A)&(B). Additionally, if a voluntary standard addressing the risk of injury has been adopted and implemented, the Commission must find that:

• the voluntary standard is not likely to eliminate or adequately reduce the risk of injury, or that

• substantial compliance with the voluntary standard is unlikely. *Id.* 2058(f)(3)(D). The Commission also must find that expected benefits of the rule bear a reasonable relationship to its costs and that the rule imposes the least burdensome requirements that would adequately reduce the risk of injury. *Id.* 2058(f)(3)(E)&(F).

III. The Product

A portable generator is an engine-driven machine that converts chemical energy from the fuel powering the engine to mechanical energy, which, in turn, is converted to electrical power. The engine can be fueled by gasoline, liquid propane, or diesel fuel.[2] A portable generator has a receptacle panel for connecting appliances or other electrical loads [3] via a cord with a plug connection. Portable generators are designed to be carried, pulled, or pushed by a person.

Portable generators that are the subject of the proposed standard commonly are purchased by household consumers to provide electrical power during emergencies (*e.g.,* power outages caused by storms), during other times when electrical power to the home has been shut off, when power is needed at locations around the home without access to electricity, and for recreational activities (*e.g.,* camping or recreational vehicle trips). Built-in wheels or optional wheel kits are often available for heavier, more powerful units (*e.g.,* units with 3 kW power ratings and more).

One of the primary features of a generator is the amount of electrical power the generator can provide on a continuous basis. This power, commonly referred to in the industry as ''rated power,'' is advertised in units of watts or kilowatts (kW), and can range anywhere from under 1 kW for the smallest portable generators, to nominally 15 kW for the largest portable generators.[4] Knowing the generator's rated power is useful in choosing the appropriate size generator for a particular electrical load, such as providing power to power tools, household appliances, or recreational equipment.

IV. Risk of Injury

A. Description of Hazard

Carbon monoxide is a colorless, odorless, poisonous gas formed during incomplete combustion of fossil fuels, such as the fuels used in engines that power portable generators. The initial effects of CO poisoning result primarily from oxygen deprivation (hypoxia) due to compromised uptake, transport, and delivery of oxygen to cells. Carbon monoxide has a 250-fold higher affinity for hemoglobin than does oxygen. Thus, inhaled CO rapidly enters the bloodstream and effectively displaces oxygen from red blood cells, resulting in the formation of carboxyhemoglobin (COHb).[5] The heart, brain, and exercising muscle are the tissues with the highest oxygen requirements; consequently, they are most sensitive to CO-induced hypoxia. The CO-induced hypoxia is reflected in the non-specific, flu-like symptoms of mild CO poisoning and early symptoms of severe poisoning, *e.g.,* headache, lightheadedness, nausea, and fatigue. More severe CO poisoning can result in progressively worsening symptoms of vomiting, confusion, loss of consciousness, coma, and ultimately, death. The high CO emission rate of current portable generators can result in situations where the COHb levels of exposed individuals rise suddenly and steeply, causing people to experience rapid onset of confusion, loss of muscular coordination, and loss of consciousness. This can occur without people first experiencing milder CO poisoning symptoms associated with a low, or slowly rising, CO level.

B. Incident Data

1. Portable Generator Carbon Monoxide Fatalities

The Commission publishes an annual report that summarizes CO incidents associated with engine-driven generators and other engine-driven tools.[6] The Commission is using this report to provide the base number of incidents for the rulemaking. CPSC staff set a date of May 21, 2015, as a cut-off for the incident data used in the briefing package. As of May 21, 2015, CPSC databases contained reports of at least 751 generator-related consumer CO poisoning deaths resulting from 562 incidents that occurred from 2004 through 2014.[7] Due to incident reporting delays, statistics for the two most recent years, 2013 and 2014, are incomplete because data collection is ongoing. Therefore, the numbers for these years will likely increase.[8] Figure 1 shows the count of deaths involving a generator derived from CPSC databases for each of these years. Note that reporting of generator-related deaths is not a statistical sample or a complete count of incidents.

[2] Engines that operate on gasoline or liquid propane are called spark ignition (SI) engines and engines that operate on diesel fuel are called compression ignition (CI) engines.

[3] An electrical load is an electrical component or portion of a circuit that consumes electric power. This is opposed to a power source, which produces power, such as a battery or generator. Examples of loads include: Appliances, lights, and power tools.

[4] As we will discuss further herein, the generator's rated power is generally a function of the size of the engine. However, there is no industry standard for relating the generator's rated power to the size of the engine; nor is there any uniform way in which electrical output capacity is advertised as ''rated.''

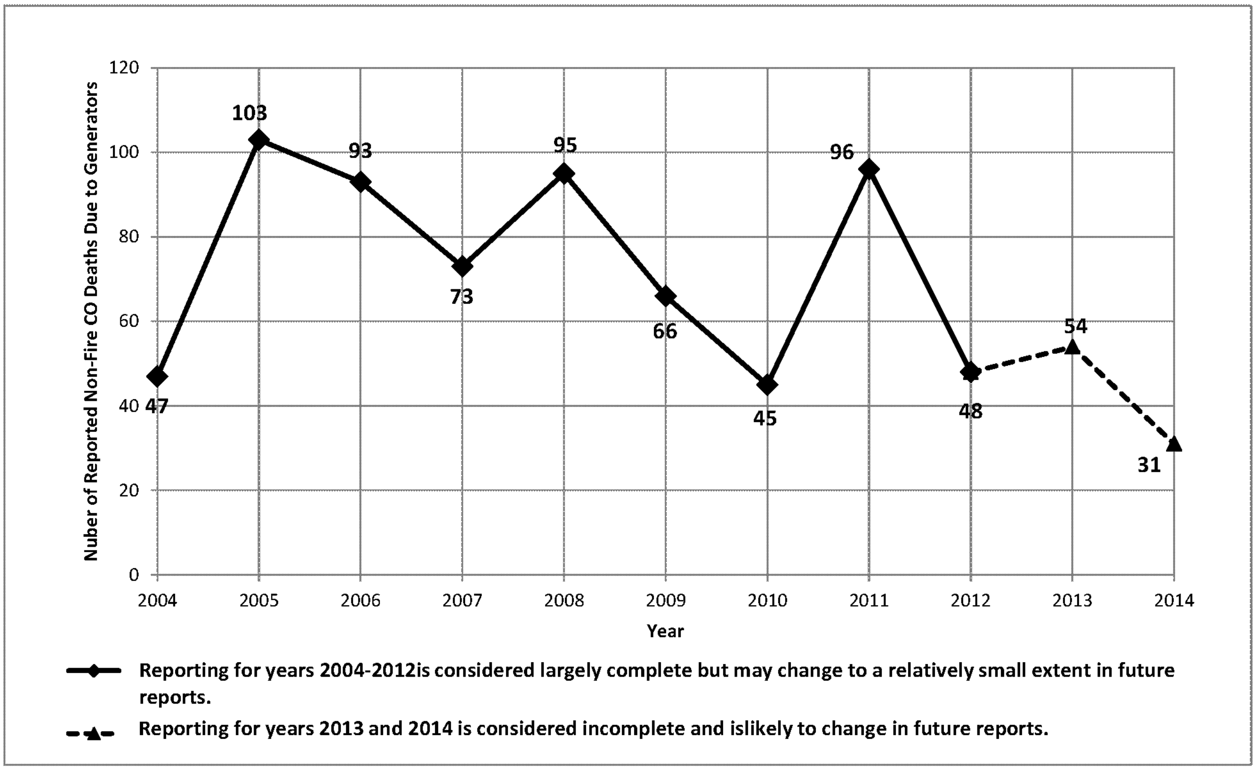
[5] COHb, expressed as a percentage, reflects the percentage share of the body's total hemoglobin pool occupied by CO. Although the relationship is not absolute, percent COHb levels can provide a useful index of CO poisoning severity. It is measured with a blood sample from the exposed person.

[6] These numbers are taken from a June 2015 reported by the CPSC, Hnatov, Matthew, *Incidents, Deaths, and In-Depth Investigations Associated with Non-Fire Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 2004–2014,* U.S. Consumer Product Safety Commission, Bethesda, MD, June 2015. (Docket Identification CPSC–2006–0057–0026, available online at: *www.regulations.gov*).

[7] Id.

[8] Note that the epidemiological benefits analysis and preliminary regulatory analysis, discussed in Sections IV and X, do not include the 85 deaths reported to CPSC as of May 21, 2015, for the years 2013 and 2014 because reporting for these years is considered incomplete. The epidemiological benefits analysis and preliminary regulatory analysis also exclude incidents involving generators that are out of the scope of the proposed rule (7 deaths in 5 incidents). Therefore, the Commission's epidemiological and regulatory analyses are based on 659 deaths in 493 incidents that occurred from 2004 through 2012.

Figure 1. Number of Reported Non-Fire Carbon Monoxide Poisoning Deaths Involving Generators Entered in CPSC Databases by Year, 2004-2014



Note: Out of the 751 deaths shown in Figure 1, sole use of a generator was responsible for 702 of these deaths, and the remaining 49 deaths involved concomitant use of a generator and another combustion product.

2. Portable Generator Carbon Monoxide Injuries

Based on CPSC's National Electronic Injury Surveillance System (NEISS) database,[9] CPSC estimates that for the 9-year period of 2004 through 2012, there were 8,703 CO injuries associated with generators seen in emergency departments (ED). This estimate should not be considered definitive because physicians have noted difficulty in correctly diagnosing these injuries. Carbon monoxide poisoning may mimic many nonfatal conditions, including alcohol or drug intoxication, psychiatric disorders, flulike illnesses, and other conditions that can lead to misdiagnosis. Measurement of COHb levels in the victim's blood, which could confirm CO poisoning, can also be confounded based on the time elapsed and any supplemental oxygen treatment administered, which can lower COHb counts prior to measurement. In addition, in some incidents, first responders transported severely poisoned victims found at the scene directly to a medical facility with a hyperbaric oxygen (HBO) chamber [10] for treatment rather than to a hospital ED. These incidents would not have been captured in NEISS. For these reasons, the Commission believes that the injury estimate for this proposed rule may be low.

In addition to using the NEISS database to estimate CO poisoning injuries for the years 2004 through 2012, the Commission examined the narratives of the 292 records of CO-related ED visits to NEISS-member hospitals associated with generators for the years 2004 through 2014. The narratives helped illustrate the range of treatments received, the symptoms, and the reasons why victims went to a hospital ED.[11]

The Commission used the Injury Cost Model (ICM) to estimate the number of injuries treated in locations other than hospital EDs. The ICM uses empirical relationships between the characteristics of injuries and victims in cases initially treated in hospital EDs and those initially treated in other medical settings (*e.g.,* physicians' offices, ambulatory care centers, emergency medical clinics), based primarily on data from the Medical Expenditure Panel Survey,[12] to estimate the number of medically attended

[9] The NEISS database is a national probability sample of hospitals in the United States and its territories. Patient information is collected from each NEISS hospital for every emergency visit involving an injury associated with consumer products. From this sample, the total number of product-related injuries treated in hospital emergency rooms nationwide can be estimated.

[10] An HBO chamber is a facility used for exposing patients to 100 percent oxygen under supra-atmospheric conditions, to shorten the time it would otherwise normally take for the CO to leave the bloodstream and to increase the amount of oxygen dissolved in the blood. A broad set of recommendations has been established for HBO treatment for CO poisoning, which includes a COHb level above 25 percent, loss of consciousness, severe metabolic acidosis, victims with symptoms such as persistent chest pain or altered mental status, and pregnant women. Treatment is not recommended for mild-to-moderate CO poisoning victims, other than those at risk for adverse outcomes.

[11] Hnatov, Matthew, *Summary of NEISS Records Associated with Carbon Monoxide Exposure Cases Related to Engine-Driven Generators in 2004 through 2014,* U.S. Consumer Product Safety Commission, Bethesda, MD, November 2015. (Docket Identification CPSC–2006–0057–0028, available online at: *www.regulations.gov*).

[12] The Medical Expenditure Panel Survey (MEPS) is a nationally representative survey of the civilian non-institutionalized population that quantifies individuals' use of health services and corresponding medical expenditures. The MEPS is administered by the Agency for Healthcare Research and Quality (U.S. Department of Health & Human Services). The MEPS has been collected continuously since 1999 and is the principal data set used to monitor medical spending in the United States.

injuries treated outside of hospital EDs. The ICM also analyzes data from the Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project[13] to project the number of direct hospital admissions bypassing the hospital EDs. According to the ICM estimates, there were an additional 16,660 medically attended CO injuries involving generators during 2004–2012. Consequently, based on NEISS and ICM estimates, there was a minimum of about 25,400 medically attended CO injuries treated during the 9-year period. This is a ratio of almost 39 generator-related CO injuries to every CO death that occurred in that period.

Table 1 presents a list of the most commonly identified symptoms given in the NEISS case narratives of 292 cases involving generator-related CO injuries that occurred in the 11-year period from 2004 through 2014. In many cases, multiple symptoms were reported, but in 29 percent of the cases (85 of 292), symptoms were not described in the NEISS narrative, although the diagnosis was reported. The weighted proportion of the total appears to account for the selection probabilities of each case.

TABLE 1—MOST COMMON SYMPTOMS REPORTED IN NEISS CO POISONING OR CO EXPOSURE CASES INVOLVING GENERATORS, 2004–2014

Common symptoms *	Cases	Weighted proportion (%)
Headache	73	27
Nausea, Felt Sick	77	30
Dizzy/Confused, Disorientation, Lightheaded	70	25
Vomiting	34	16
Passed Out, Unconscious, Unresponsive	18	5

* Cases may appear multiple times in Table 1 because victims may have exhibited multiple symptoms.

Table 2 presents a summary of the reasons why the patients said they went to the emergency room for treatment or to be checked out. In the majority of cases, the medical records, from which the narratives were abstracted, provided little or no information on how the patients knew they needed to go to the emergency room or how they got there. However, in 47 of the 93 cases in which this information was available, the patient realized something was wrong and arranged to get to the emergency room.

TABLE 2—REASON VICTIM WENT TO ED FOR NEISS CO POISONING OR CO EXPOSURE CASES INVOLVING GENERATORS, 2004–2014

Reason	Cases	Weighted proportion (%)
Victim realized something was wrong and arranged to get to ER	47	23
Discovered in distress by family, friend, or due to a welfare check	24	6
Carbon monoxide alarm sounded, arranged to get to ER	22	9
Unknown why or how taken to Emergency Room	199	62
Total	292	100

Table 3 presents a summary of the location of the generator involved with the CO poisoning event. The three most common locations identified were ''Inside the home'' (33%); ''Inside the garage'' (25%); and ''In the basement'' (18%). In 11 percent of the reported cases, the generator was located outside. In half of the ''Outside the home'' scenarios, the narrative specifically states the location was near a window, door, or air conditioner.

TABLE 3—LOCATION OF GENERATOR IN CASES REPORTED IN NEISS CO POISONING OR CO EXPOSURE CASES ASSOCIATED WITH GENERATORS, 2004–2014

Generator location	Cases	Weighted proportion * (%)
Inside the home	86	33
Inside the garage	70	25
In the basement	56	18
Outside the home	29	11
Other/Unknown	51	14
Total	292	100

* Percentages do not sum to 100% due to rounding.

The high number of estimated injuries relative to fatalities suggests that many more people leave the scene of the generator, are rescued, or seek care than fatally succumb to CO poisoning. As detailed in subsequent sections, reduced CO emissions will greatly extend the time it takes for CO exposures to result in incapacitation and subsequent death. Moreover, in some cases, reduced CO emissions will actually prevent incapacitation and death from happening, even if an individual does not leave the exposure location. In situations where a generator is operated indoors, the extended window of time will allow exposed individuals a much greater chance of terminating their CO exposure or increase the chance of being found by others before serious injury and/or death can occur. Exposure termination could occur for several reasons, including the following:

- Exposed individuals might leave the exposure location to engage in everyday activities (*e.g.,* work, school),

[13] The National (Nationwide) Inpatient Sample (NIS) is part of a family of databases and software tools developed for the Healthcare Cost and Utilization Project (HCUP). The NIS is the largest publicly available all-payer inpatient health care database in the United States, yielding national estimates of hospital inpatient stays. HCUP is a family of health care databases and related software tools and products developed through a federal-state-industry partnership and sponsored by the Agency for Healthcare Research and Quality (U.S. Department of Health & Human Services).

without necessarily being aware of any developing CO hazard.

- In some cases, exposure termination might occur without the individual leaving the location, simply because the generator runs out of fuel, or power is restored and the generator is shut down in response, which allows CO levels to decay naturally without reaching lethal exposure.
- Exposed individuals might respond to a CO alarm activation.
- Exposed individuals might recognize a growing health concern and leave to seek treatment or summon help (call a friend, relative, or 9–1–1), even if they do not necessarily recognize CO emissions as the cause of early nonspecific adverse health effects of CO poisoning.
- Exposed individuals might be found in an impaired state by other, lesser affected, co-exposed individuals who had been in locations farther away from the generator.
- Exposed individuals might be found by concerned outside parties conducting welfare checks, or by outside parties simply arriving at their home for other reasons, such as, to co-commute to work, a social or official visit, or the return home of a co-occupant from work or school.

The Commission notes that all the reasons specified above for exposure termination have been reported in incidents where there are survivors of carbureted, generator-related CO poisoning. More such cases would be expected with reduced CO emissions, due to an overall downward shift in expected CO poisoning severity. The Commission recognizes that consumers cannot be relied upon to react appropriately to any indication of a CO exposure, and that even those who recognize a developing CO hazard, might decide to enter the area where a generator is located in an attempt to switch it off. This behavior is known to have resulted in lethal outcomes with carbureted generators because CO can accumulate to levels that can cause near-immediate loss of consciousness due to hypoxia/anoxia. However, with reduced CO emissions, the peak CO levels attained in an unventilated area where the generator is operated will be considerably lower than the level that would cause near-immediate loss of consciousness. This potentially could reduce the incidence of death among individuals who enter an unventilated area to turn off a generator, by allowing them time to egress the area before being overcome.

C. Hazard Characteristics

As stated in the previous section, as of May 2015, there were 562 incidents involving fatalities from portable generators reported to CPSC, which occurred between 2004 through 2014. CPSC assigned In-Depth Investigations (IDI) for 535 of these 562 incidents (95 percent), to gather more detailed information about the incident and the product(s) in use. CPSC categorized the incident data in the IDI reports according to the location where the incident occurred:

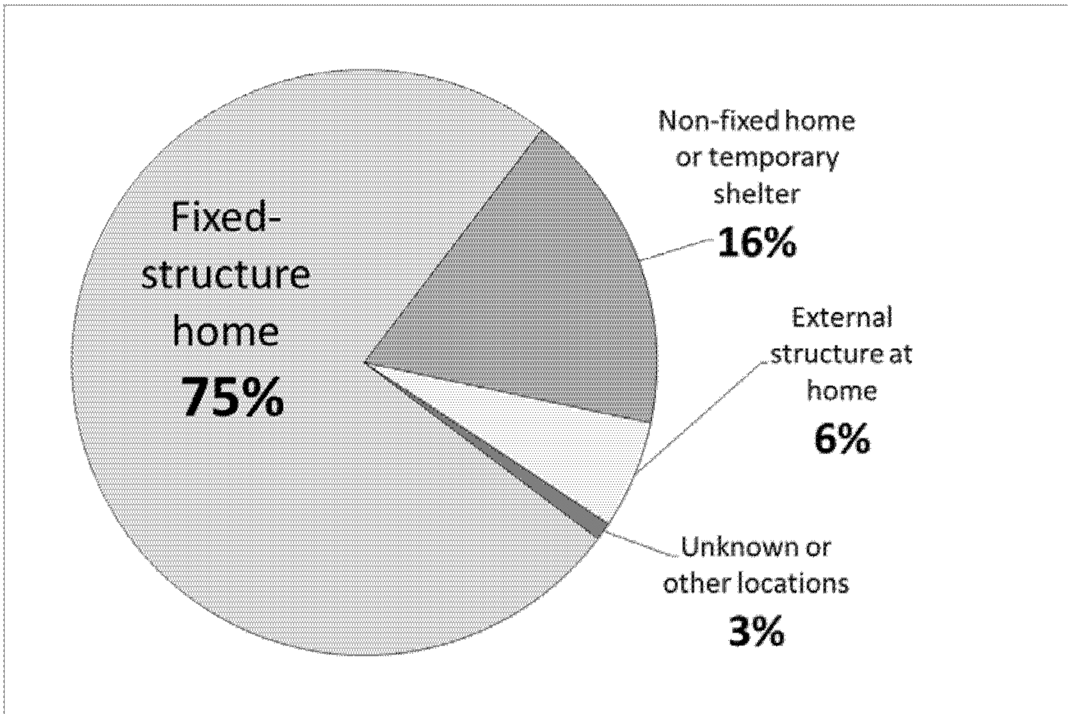
- 75 percent of deaths (565 deaths, 422 incidents) occurred in a fixed-structure home location, which includes detached and attached houses, apartments, fixed mobile homes, and cabins used as a permanent residence;
- 16 percent (117 deaths, 81 incidents) occurred at non-fixed-home locations or temporary structures, such as trailers, horse trailers, recreational vehicles (RV), cabins (used as a temporary shelter), tents, campers, and boats, and vehicles in which the consumer brought the generator on board or into the vehicle;
- 6 percent (48 deaths, 46 incidents) occurred in external structures at home locations, such as sheds and detached garages;
- 3 percent (21 deaths, 13 incidents) occurred at unknown or other locations.

In the same 11-year period, 42 deaths from 30 incidents [14] occurred with the generator operating outdoors, where the exhaust infiltrated into a nearby fixed-structure home, a non-fixed-structure home, or temporary shelter.[15] See Figure 2.

[14] These figures exclude two deaths in 2011 caused by a stationary generator operated outdoors.

[15] Hnatov, Matthew, *Carbon Monoxide Deaths Associated with Engine-Driven Generators Located Outdoors in 2004 through 2014,* U.S. Consumer Product Safety Commission, Bethesda, MD, November 2015. (Docket Identification CPSC–2006–0057–0028, available online at *www.regulations.gov*).

Figure 2. CO Deaths Associated with Generators by Location of the Incident, 2004-2014



Of the 565 deaths (422 incidents) that occurred at a fixed structure home:

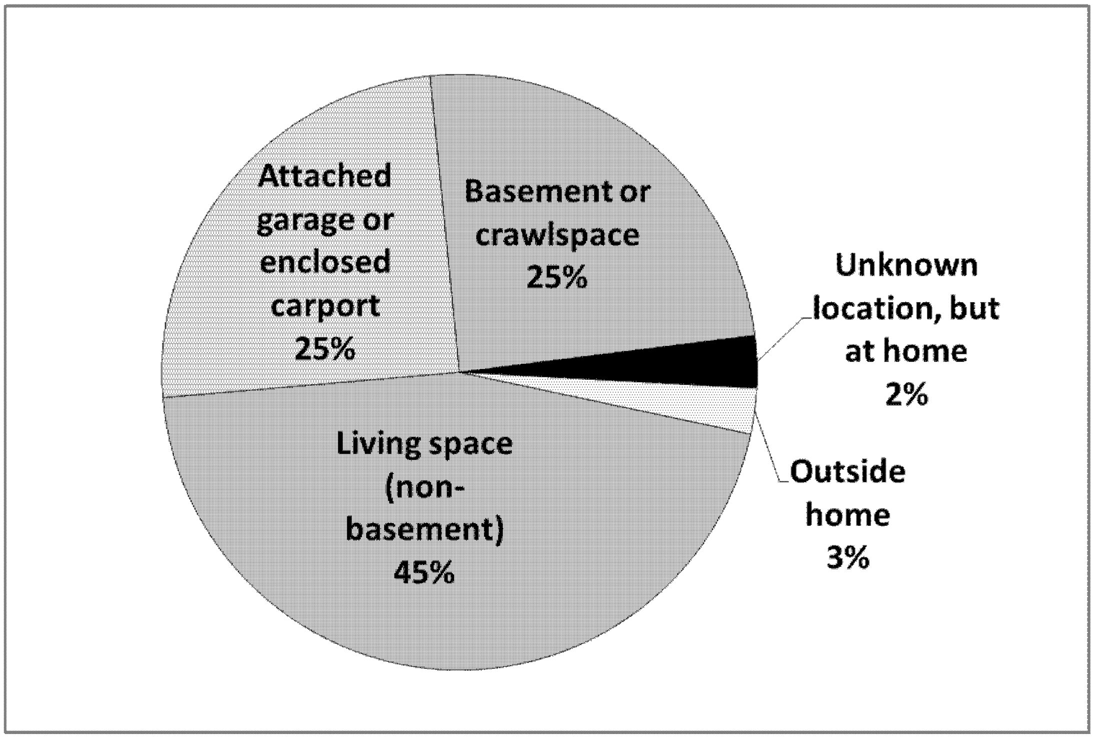
- 45 percent (256 deaths, 191 incidents) occurred when the generator was operated in the living space[16] of the house;
- 25 percent (140 deaths, 108 incidents) occurred when the generator was in the attached garage or enclosed carport;
- 25 percent (139 deaths, 98 incidents) occurred when the generator was in the basement or crawlspace;
- 3 percent (16 deaths, 12 incidents) occurred when the generator was operated outside;[17]
- 2 percent occurred when the generator was at the fixed-structure home site, but exact location was unknown.

See Figure 3.

[16] Used here, living space includes all rooms, closets, doorways and unidentified areas inside a home, but does not include basements, which are treated as a separate category.

[17] Another 28 deaths from 19 incidents occurred with generators operating outside structures other than fixed-structure home sites, such as RV, camper or trailer, vehicle, boat, or cabin used other than as a permanent residence.

Figure 3. CO Incidents Involving Generators that Occurred in a Fixed Structure Home Location, by Specific Location of the Generator, 2004-2014



The reason the generator was needed was identified in more than 80 percent of the 562 incidents. Following are the three biggest causes:

- 27 percent (152 incidents) were associated with the use of generators during a temporary power outage stemming from a weather problem or a problem with power distribution;
- 21 percent of the fatal incidents (116 incidents) were associated with the use of generators after a power shutoff by the utility company for nonpayment of a bill, a bill dispute, or other reason.
- 19 percent of the fatal incidents (109 incidents) did not indicate why the generator was in use, or why there was no electricity at the location of the incident.

Of the 152 fatal incidents associated with a power outage due to weather or a problem with power distribution, 93 percent were due to specific weather conditions. Ice or snow storms are associated with the largest percentage of weather-related CO fatal incidents, accounting for nearly half (49%) of the power outage-related incidents. Hurricanes and tropical storms were associated with 28 percent of CO fatal incidents. More than half (31 of 61) of the generator-related CO fatalities that were hurricane- or tropical storm-related (20 of 42 fatal incidents) occurred in 2005, a year of above-average hurricane activity.

The size of the generator involved in a CO fatality was identified in 45 percent of the 562 incidents. Because most of the generators that were associated with fatal CO poisoning were gasoline-fueled,[18] staff categorized the size of the generator by using the U.S. Environmental Protection Agency's (EPA) classification of the small SI engine powering it: A handheld engine [19]; a non-handheld, Class I engine; or a non-handheld, Class II engine.[20] The incidents involving generators powered by non-handheld, Class II engines were then divided by whether the engine had a single cylinder or twin cylinders.[21] In the majority of cases (55%), CPSC staff was unable to obtain sufficient information to be able to categorize the generator into one of these classifications. In the incidents where engine classification could be determined, slightly more than one-third (35 percent) involved Class I engine powered generators, and slightly less than two-thirds (63 percent) involved single-cylinder, Class II

[18] In 52 of the 562 incidents, the fuel type could not be ascertained. Of the 510 cases where the fuel type used in the generator was known, 99 percent (506 of 510) were gasoline-fueled generators. Of the remaining incidents, three involved propane-fueled generators, and the other incident involved a diesel-fueled generator.

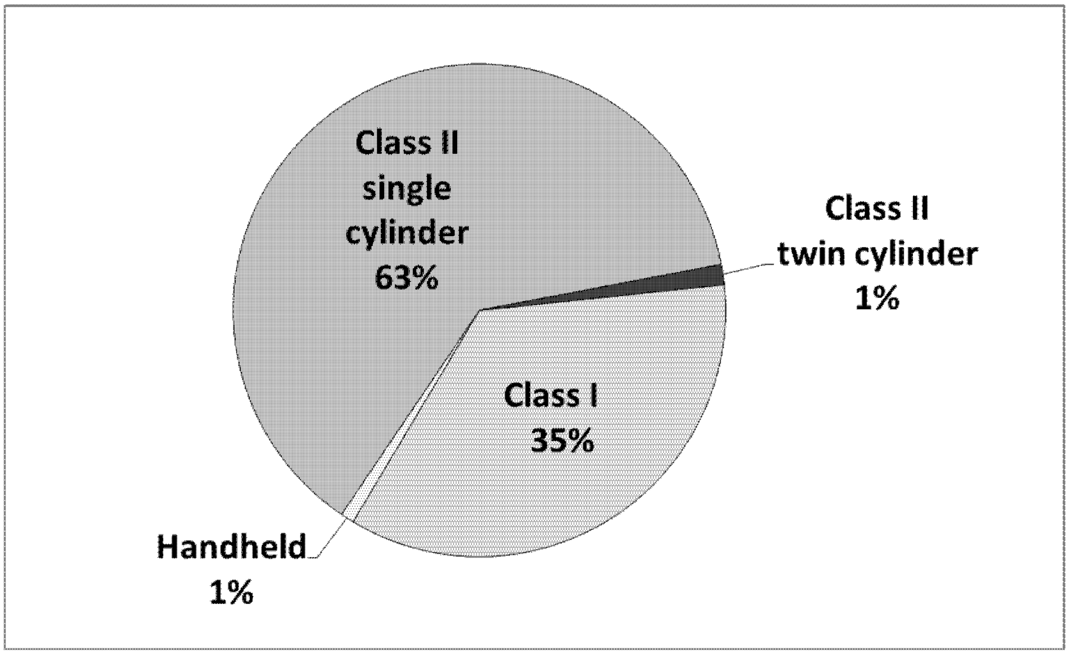
[19] Although handheld engines generally are used in equipment that is held or supported by an operator during use (such as trimmers), handheld engines may also be used to power non-handheld equipment, such as smaller portable generators.

[20] The EPA broadly categorizes small SI engines as either non-handheld or handheld, and within each of those categories, further distinguishes them into different classes, which are based upon engine displacement. Non-handheld engines are divided into Class I and Class II, with Class I engines having displacement above 80 cc up to 225 cc, and Class II engines having displacement at or above 225 cc, but with maximum power of 19 kilowatts (kW). Handheld engines, which are divided into Classes III, IV, and V, are all at or below 80 cc.

[21] When the IDI did not report the generator's engine displacement, or it was not obtainable from other information in the IDI, staff considered the power rating of the generator, if the IDI contained information regarding the power rating of the generator. Staff classified generators with a reported wattage of 3.5 kW and larger as powered by a Class II engine and those less than 3.5 kW as powered by either a handheld or a Class I engine. To distinguish the handheld powered generators from the Class I powered generators when there was no information to ascertain the engine displacement, generators with wattage of 2 kW to 3.5 kW were considered to have a Class I engine. To distinguish the single-cylinder Class II engines from the twin-cylinder Class II engines, staff determined from a search of EPA's exhaust emission certification database (*www3.epa.gov/otaq/certdata.htm#smallsi*) that twin-cylinder, class II engines generally have a maximum engine power of nominally 12 kW and higher. Based on manufacturers' generator specifications available online, generators with engines with power equal to or greater 12 kW, typically have a rated power of 9kW and higher. Therefore, staff considered generators with rated power of 3.5 kW up to 9 kW to be powered by a single-cylinder, Class II engine, and those 9 kW and greater to be powered by a twin-cylinder, Class II engine when there was no information to ascertain the engine displacement and number of cylinders.

engine-powered generators. See Figure 4. There were two incidents involving generators powered by handheld engines that caused one death in each incident. There were three incidents involving generators powered by twin-cylinder, Class II engines that caused seven deaths. Two of the incidents were single-death incidents, and the third incident, with the generator operating outside an RV, caused five deaths inside the RV.

Figure 4. Size of Generator Engine Involved In CO Incidents, When Engine Size Was Identified, 2004-2014



V. Overview of Proposed Requirements

The proposed standard would apply to portable generators powered by small handheld and non-handheld SI engines. The Commission categorized the size of the generator using the EPA's classification of the small SI engine powering it: A handheld engine, a non-handheld Class I engine, or a non-handheld Class II engine. The Commission further categorized the generators powered by non-handheld Class II engines by whether the engine had a single cylinder or twin cylinders. The Commission defines the *generator* categories (as distinguished from the *engine* categories) as follows:

- A *handheld generator* is a generator powered by an SI engine with displacement of 80 cc or less;
- A *class 1 generator* is a generator powered by an SI engine with displacement greater than 80 cc but less than 225 cc;
- A *class 2 single cylinder generator* is a generator powered by an SI engine with one cylinder having displacement of 225 cc or greater, up to a maximum engine power of 25 kW; and
- A *class 2 twin cylinder generator* is a generator powered by an SI engine with two cylinders having a total displacement of 225 cc or greater, up to a maximum engine power of 25 kW.

Although the Commission categorized generators based on the EPA classification of the engines powering them, it is important to distinguish these engines from the portable generators that they are used in because the engines are also used in other products. To provide a clear distinction, the Commission refers to *engines* according to EPA's classification: Handheld engines, non-handheld Class I engines, and non-handheld Class II engines, while referring to *portable generators* according to the Commission's definitions, handheld generators, class 1 generators, class 2 single-cylinder generators and class 2 twin-cylinder generators.

Generators within the scope of the proposed rule provide receptacle outlets for AC output circuits and are intended to be moved, although not necessarily with wheels. Products that would not be covered by the proposed rule include permanently installed stationary generators, 50 hertz generators, marine generators, generators permanently installed in recreational vehicles, generators intended to be pulled by vehicles, generators intended to be mounted in truck beds, and generators that are part of welding machines. Generators powered by compression-ignition (CI) engines (engines fueled by diesel) are also excluded from the scope of the proposed rule. These inclusions and exclusions are largely consistent with the scope of the two U.S. voluntary standards for portable generators, UL 2201—*Safety Standard for Portable Generator Assemblies* and PGMA G300—*Safety and Performance of Portable Generators.*

The great majority of the units that fall within the scope of the proposed standard are gasoline-fueled, but portable generators powered by engines fueled by liquid propane (LP) present similar risks of CO poisoning, and these units also would be covered by the proposed rule. Some portable generators can operate fueled by gasoline, LP and natural gas, and these would also be covered by the scope of the proposed rule.

The proposed rule specifies different limits on weighted carbon monoxide emission rates for different classes of generators in recognition of the effects of factors such as engine size and other engine characteristics on CO emissions, generator size, weight, and hazard patterns and the different challenges that may be faced in meeting CO emission rates expressed in grams per hour. The performance requirements for the different classes of generators also have a scaling factor of 1.5 applied to the technically feasible rates to account for production variation. Specifically, the proposed rule would require that handheld generators and class 1 generators not exceed a weighted CO rate of 75 grams per hour (g/hr); class 2 single-cylinder generators not exceed a weighted CO emission rate of 150 g/hr; and class 2 twin-cylinder generators not exceed a weighted CO emission rate of 300 g/h. The weighted emission rates are based on weighting of six modes of generator operation, ranging from maximum generator load capability (mode 1) to no load (mode 6), similar to a procedure used by EPA to certify compliance with its emission standards for small SI engines. More detail about this procedure can be found in CPSC's staff briefing package. The performance requirements apply when generators operate at normal oxygen content; however, the Commission remains interested in CO emissions when generators operate at reduced oxygen content of 17 percent. The Commission welcomes comments on the advantages and disadvantages of setting performance requirements at 17 percent oxygen instead of normal oxygen as well as comments on the technically feasible CO emission rates for generators operating at 17 percent oxygen, for each of the generator categories. Furthermore, the Commission welcomes comments on the test methods for CO emissions in both normal oxygen and 17 percent oxygen in Tab J, Appendices A2 and A3 of the staff's briefing package.

The proposed rule does not dictate how generators would meet the CO emission limits. Rather, under the proposed rule, firms have the flexibility to determine the appropriate technology to meet the specified performance requirements. To determine feasibility and to estimate likely costs of the proposed rule, staff's briefing package, and this preamble, discuss ways that staff believes companies might modify generators to meet the CO emission limits. However, companies could use other approaches.

The proposed rule describes the test procedure and equipment that the Commission would use to assess compliance with the standard. Manufacturers, however, need not use this particular test, so long as the test they use effectively assesses compliance with the standard. The Commission believes this approach provides added flexibility to manufacturers to reduce testing burdens. The Commission welcomes comments on the benefits and costs of this approach versus requiring a specifc test method for manufacturers to demonstrate compliance.

In accordance with Section 9 of CPSA, the proposed rule contains a provision that prohibits a manufacturer from ''stockpiling,'' or substantially increasing the manufacture or importation of noncomplying generators between the date that the proposed rule may be promulgated as a final rule, and the final rule's effective date. The rule would prohibit the manufacture or importation of noncomplying portable generators by engine class in any period of 12 consecutive months between the date of promulgation of the final rule and the effective date, at a rate that is greater than 125% of the rate at which they manufactured or imported portable generators with engines of the same class during the base period for the manufacturer. The base period is any period of 365 consecutive days, chosen by the manufacturer or importer, in the 5-year period immediately preceding promulgation of the rule.

Generator sales can vary substantially from year to year, depending upon factors such as widespread power outages caused by hurricanes and winter storms. Annual unit shipment and import data obtained by CPSC staff show that it has not been uncommon for shipments to have varied by 40 percent or more from year to year at least once in recent years. The anti-stockpiling provision is intended to allow manufacturers and importers sufficient flexibility to meet normal changes in demand that may occur in the period between promulgation of a rule and its effective date, while limiting their ability to stockpile noncomplying generators for sale after the effective date. The Commission seeks comments on the proposed product manufacture or import limits and the base period for the stockpiling provision.

VI. CPSC Technical Analysis and Basis for Proposed Requirements

A. CPSC's Two-Part Prototype Low CO Emission Generator Technology Demonstration Program

CPSC staff developed a two-part technology demonstration program to demonstrate that the small SI engine powering a commercially available portable generator could be modified with existing emission control technology to reduce its CO emission rate to levels expected to reduce the risk of fatal and severe CO poisoning. The objective of the first part of the program was to develop, from a current carbureted engine-driven generator, a prototype with a CO emission rate reduced to the lowest technically feasible level: (1) Without negatively impacting the engine's power output, durability, maintainability, fuel economy, and risk of fire and burn; and (2) while also ensuring that the engine continued to meet EPA's small SI engine exhaust emission standard for hydrocarbons and oxides of nitrogen ($HC+NO_X$), to which the unmodified OEM version of the engine was originally labeled as being certified. For this, CPSC staff sought a target CO emission rate reduction of 90 percent. The objective of the second part of the program was to assess the efficacy of the prototype generator in reducing occupant exposure profiles created by its operation in a fatal scenario commonly reported in CPSC's incident data compared to the exposure profiles created by the unmodified carbureted generator.[22]

Part One: Prototype Development and Durability Testing at University of Alabama

The Commission contracted with the University of Alabama (UA) to conduct the prototype development and durability phase of the program. The prototype development started with a commercially available generator with an advertised continuous electrical power output rating of 5.0 kW that was powered by a small, air-cooled, single-cylinder non-handheld Class II carbureted engine with a 389 cubic centimeter (cc) displacement and overhead valve (OHV) configuration. The prototype was a modification of that engine. To develop the prototype, UA replaced the engine's carburetor with a closed-loop electronic fuel-injection (EFI) system, used an oxygen sensor in the exhaust for closed-loop fuel-control feedback, tuned the fuel control to stoichiometry[23] and replaced the muffler with a muffler that had a small three-way catalyst (TWC) integrated into it. UA subjected the

[22] Complete documentation on the prototype generator and both parts of the demonstration program is provided in Buyer, Janet, *Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator,* September 2012. (available online at: *http://www.cpsc.gov/PageFiles/129846/portgen.pdf* and in *www.regulations.gov* in docket identification CPSC–2006–0057–0002).

[23] Stoichiometry is the theoretical air-fuel ratio (AFR) for complete combustion and is the theoretical point for nearly the lowest amount of CO production. AFR associated with stoichiometry for typical gasoline formulations is nominally 14.6.

prototype generator to a durability program for a total of 500 hours, which was the manufacturer's rated useful life of the engine at the time of the program. Simultaneous to the durability program on the prototype generator, UA subjected a baseline unmodified carbureted generator, the identical model to the prototype generator before modification, to the same durability program. UA made periodic emission measurements on both the prototype and the unmodified carbureted generator during the 500 hours of operation to compare the performance of the prototype to the baseline unmodified carbureted generator. After the 500-hour durability program concluded on both the baseline carbureted generator and the prototype generator, an independent laboratory, Intertek Carnot Emission Services (CES), conducted end-of-life emission testing, both with the engine installed in the generator as well as on a dynamometer,[24] in accordance with the EPA small SI engine test procedures. The purpose of this testing was to ascertain whether, at the end of the engine's rated useful life, the prototype engine's emissions would meet: (1) The EPA's Phase 2 requirements for $HC+NO_X$, and (2) CPSC staff's target reduction for the exhaust CO emission rate.

CES's testing in accordance with EPA test procedures showed that the prototype engine, while mounted on a dynamometer and equipped with the muffler that had a catalyst installed, had a 6.0 g/kW-hr CO emission rate. This CO emission rate is 99 percent below the EPA's Phase 2 and Phase 3 CO standard of 610 g/kW-hr.[25] The prototype engine had an $HC+NO_X$ exhaust emission rate of 6.7 g/kW-hr. This rate is 45 percent below the EPA's Phase 2 $HC+NO_X$ standard for a Class II engine, to which the engine was originally certified, and 16 percent below the Phase 3 $HC+NO_X$ standard that came into effect shortly after CPSC's development program with UA began. CES's dynamometer testing also showed that the prototype engine delivered a maximum power of 7.9 kW, which is within 0.3 kW of the advertised rated power for the unmodified OEM carbureted engine. CES's emission testing of the prototype generator (with the engine still installed in the generator, as opposed to mounted on the dynamometer) measured a weighted CO emission rate of 26.10 g/hr.[26] Thus, at the end of the engine's rated useful life, the prototype engine's emissions met both EPA's Phase 2 requirements for $HC+NO_X$ and CPSC staff's target reduction for the exhaust CO emission rate. Staff's prototype findings have since been repeated by others who patterned their reduced CO emissions prototype generators on the design concept developed for CPSC by the University of Alabama.[27] Moreover, new generator products with reduced CO emissions, achieved by similar engine design modifications and use of catalysts, are beginning to enter the retail market.[28]

Part Two: Comparative Testing of Unmodified Carbureted (Baseline) and Prototype Generators at National Institute for Standards and Technology

The Commission entered into an interagency agreement with NIST to conduct the second part of the program. In this part of the demonstration program, NIST operated one generator in its unmodified carbureted configuration and another generator in the prototype configuration in the attached garage of a test house on NIST's campus. The test house is used for conducting indoor air quality (IAQ) studies. NIST measured the CO accumulation in the garage and transport into the house. The results provide a sense of how quickly a commonly fatal consumer scenario develops with an existing carbureted generator, and what the comparative results are from the same tests with the fuel-injected catalyzed prototype.[29]

NIST compared the garage CO concentrations from the prototype and the unmodified carbureted generator, after equal periods of generator run-time in the tests, with the garage bay door fully closed. NIST found that the prototype showed 97 percent reduction in the amount of CO released into the garage, compared to the unmodified carbureted generator. This reduction is consistent with UA's findings and translated to much lower levels of CO transporting throughout the house. Taking into consideration the CO time course profile (which is the CO concentration over time) of each room of the house and of the garage, the Commission performed health effects modeling and estimated that the prototype generator resulted in a significantly extended time interval for hypothetical occupants to escape or to be rescued before being incapacitated. For example, in one test in which the garage bay door and connecting door to the house were both closed, the time interval increased by a factor of 12 with the prototype, compared to the unmodified carbureted generator (from 8 minutes to 96 minutes) for the deadly scenario of a consumer in the garage with the generator. The time interval increased even more for occupants inside the house.

The Commission believes that this increased time interval could give occupants an opportunity to remove themselves from the exposure before being incapacitated (perhaps due to their symptoms or other reasons such as an unrelated need to leave the house) or to be found alive by others. In contrast, the Commission predicts that the high CO emission rate of the unmodified carbureted generator would cause some of the occupants, depending on where they are located, to experience relatively quick onset of confusion, loss of muscular coordination, loss of consciousness, and death, without having first experienced milder CO poisoning symptoms associated with low or slowly rising CO-induced hypoxia.

B. Staff Assessment of Feasible CO Rates Based Upon EPA's Technology Demonstration Program and Staff Testing of Fuel-Injected Generators

A technology demonstration conducted by EPA further demonstrates the feasibility of significantly lowering CO emission generators using EFI.[30] In

[24] A dynamometer is an instrument that measures the power output of an engine.

[25] The EPA sets emission standards for all small SI engines. These engines provide power for a wide range of products typically owned by consumers, including portable generators. The EPA's primary emphasis is on regulating emissions that contribute significantly to nonattainment of the National Ambient Air Quality Standards (NAAQS) for ozone, of which hydrocarbons and oxides of nitrogen ($HC+NO_X$) are precursors. For non-handheld engines, the EPA adopted emission standards referred to as Phase1 in 1995, Phase 2 in 1999, and Phase 3 in 2008.

[26] The highest of three tests was 26.10 g/hr. The other two tests yielded weighted CO rates of 23.47 and 19.38 g/hr.

[27] See Techtronic Industries (TTi) presentation on 3/17/16, at PGMA's Technical Summit on Carbon Monoxide Hazard Mitigation for Portable Generators—pages 85–105 of 178 page pdf file at: *http://www.cpsc.gov//Global/Newsroom/FOIA/Meeting%20Logs/2016/MeetingLogPGMA31716.pdf.*

[28] See Tab I staff's briefing package.

[29] Another objective of the IAG was to determine each generator's mass CO emission rates at each of the six loads used in the load profile. This work also supported NIST's validation of NIST's multizone airflow and contaminant transport model CONTAM, which is used to predict contaminant concentrations throughout a modeled structure resulting from a source mass emission rate located somewhere within the structure. NIST used CONTAM in predicting the health effects of the CO rates associated with the proposed performance requirements.

[30] McDonald, Joseph, Olson B, and Murawski M, *Demonstration of Advanced Emission Controls for Nonroad SI Class II Engines,* SAE paper 2009–01–1899; McDonald, Joseph, Memorandum, Re: Supplemental Engine Dynamometer Data, May 5, 2006. (available online in: *www.regulations.gov* in

Continued

2006, EPA examined the feasibility of reducing HC+NO_X emissions beyond their Phase 2 standards.[31] EPA applied EFI and high-efficiency catalysts on two single-cylinder, air-cooled engines, both nominally 500 cubic centimeters (cc) in displacement with overhead valve (OHV) configurations. Because CO and NO_X emissions have an inverse relationship, in focusing on reducing HC+NO_X emissions, EPA specifically chose to test with catalysts formulations designed to *minimize* CO oxidation.[32]

EPA used low-cost engine management and fuel injection systems that were similar to that which UA used for the CPSC prototype generator. While the UA generator prototype used a closed-loop system and tuned the fuel to stoichiometry at the high loads, in interest of cost-savings, the EPA engines did not use an oxygen sensor necessary to make it a closed-loop fuel system. For its engines, EPA replaced the carburetor with open-loop EFI that was calibrated rich of stoichiometry, *i.e.,* a lower air-to-fuel ratio, at moderate-to-high loads and near stoichiometry at light load conditions to achieve the desired emission control of HC+NO_X. EPA developed integrated catalyst-muffler systems for its engines, all selected to prioritize NO_X reduction and HC oxidation over CO oxidation. Even though EPA was intentionally trying to select catalysts that would *minimize* CO oxidation, both engines achieved an average 68 percent reduction in the weighted CO emission rate. The average of the weighted CO emission rate of the two carbureted OEM configurations was 1,760 g/hr, and the average of the two EFI configurations with the catalyst providing the most reduction in CO emissions was 565 g/hr.

Although the EPA noted that some engines may need improvements to accommodate stoichiometric fuel control (such as redesign of cooling fins, fan design, combustion chamber design, and a pressurized oil lube system), EPA concluded that closed-loop EFI with fuel control at or near stoichiometry *is* technically feasible and *is not* cost prohibitive on all Class II engines.[33]

CPSC staff believes that with a focus on reducing CO emissions, a lower weighted CO emission rate could have been achieved by using an oxygen sensor for closed-loop feedback, operation closer to stoichiometric at the higher loads, and a different catalyst formulated for higher conversion efficiency of CO.[34]

CPSC staff tested three fuel-injected generators created by three different manufacturers.[35] Two of these generators, neither of which was designed for low CO emissions, are available in the marketplace, and the third is a manufacturer's prototype generator that was designed for low CO emissions. The first of the three generators is a 10.5 kW rated generator powered by a twin-cylinder Class II engine with nominal 700 cc displacement and overhead valve (OHV) configuration. The generator does not have a catalyst for aftertreatment and the generator's engine is calibrated rich of stoichiometry at higher loads and at stoichiometry with closed-loop fuel control at moderate-to-light load conditions. Based on CPSC staff's testing of this generator in normal atmospheric oxygen, which found a 670 g/hr weighted CO emission rate, as well as on staff's engineering assessment of its physical and operational characteristics, staff believes that it is reasonable to expect that this engine could operate closer to stoichiometric at the higher loads and that a catalyst formulated for some CO conversion efficiency could be used for aftertreatment to further reduce its CO emission rate to nominally 200 g/hr.

The second generator is a 5.5 kW rated power generator powered by a single-cylinder Class II engine with nominal 400 cc displacement and OHV configuration, equipped with an oxygen sensor for some form of partial closed-loop operation and a catalyst. The engine is calibrated rich of stoichiometry at all loads. Based on staff's testing in normal atmospheric oxygen that found a nominal weighted CO rate of 560 g/hr, staff believes a CO emission rate of nominally 100 g/hr is possible, if the generator were operated closer to stoichiometric for at least some of the loads and used a catalyst formulated for higher CO conversion efficiency.

The third generator is a 5.5 kW rated power generator powered by a closed-loop fuel-injected single-cylinder Class II engine with nominal 400 cc displacement and OHV configuration. It has a catalyst for aftertreatment and the engine is calibrated to stoichiometric AFR with closed-loop operation at all loads. Staff's testing of this generator in normal atmospheric oxygen found a weighted CO rate of 81 g/hr.

C. Assessment of Epidemiological Benefits of Reduced CO Emission Portable Generators—NIST CO and COHb Modeling Study

1. Background

To assess the epidemiological benefits of reduced CO emission generators, CPSC contracted NIST to perform a series of CO exposure simulations that would model the operation of a portable generator in various locations within various house configurations and other structures, and at various CO emission rates.[36] CPSC used these results to determine the possible deaths averted if reduced CO emission generators had been used, as described below.

2. CO Emission Modeling

NIST modeled 40 different structures, including houses with basements and others with crawlspaces, as well as ones with slab-on-ground construction, with and without attached garages, and including older construction and newer construction homes. Three different external residential structures designed to represent detached garages and sheds were included in the 40 structures. The 37 different house models included detached home, attached home, and manufactured home designs. House models and other structures used in the modeling study were matched to 503 out of the 659 actual generator-related CO fatalities reported to CPSC over the period 2004 to 2012. One hundred fifty-six fatalities (659 minus 503) were not included in the modeling analysis because the generator was either outdoors or in a structure such as a camper, RV, tent, church, boat, or apartment complex that was not similar to any of the structure models used by NIST. The Commission believes that reduced emission generator use in these scenarios would most likely have produced fewer CO fatalities than the number observed in the incident data.

docket identification EPA–HQ–OAR–2004–0008–0372.).

[31] U.S. EPA, *Control of Emissions from Marine SI and Small SI Engines, Vessels, and Equipment—Final Regulatory Impact Analysis,* EPA420–R–08–014, September 2008 (available online in *www.regulations.gov* in docket identification EPA–HQ–OAR–2004–0008–0929); U.S. EPA, *EPA Technical Study on the Safety of Emission Controls for Nonroad Spark-Ignition Engines <50 Horsepower,* EPA420–R–06–006, March 2006, Docket Identification EPA–HQ–OAR–2004–0008–0333. (available online at: (*http://www.epa.gov/nonroad/equip-ld/phase3/420r06006-rpt-2appdx.pdf*).

[32] Oxidation of CO to carbon dioxide (CO_2) is the means by which CO emissions are reduced in a catalyst.

[33] U.S. EPA, *EPA Technical Study on the Safety of Emission Controls for Nonroad Spark-Ignition Engines <50 Horsepower,* EPA420–R–06–006, March 2006, Docket Identification EPA–HQ–OAR–2004–0008–0333. (available online at: (*http://www.epa.gov/nonroad/equip-ld/phase3/420r06006-rpt-2appdx.pdf*).

[34] See CPSC staff's briefing memorandum and Tab I of the briefing package for a more detailed explanation.

[35] See Tab I of the staff's briefing package.

[36] Emmerich, Steven J., B. Polidoro, W. Dols, Simulation of Residential CO Exposure Due to Portable Generator Operation in Enclosed Spaces (NIST Technical Note 1925), 2016.

This would be especially true in scenarios with the generator running outdoors, or in a large-volume space, such as a church.

CPSC staff chose the modeled CO emission rates based on: (1) CPSC's estimates of elevated CO emission rates expected for the four categories of current carbureted generator products when operating in a reduced oxygen environment, and (2) a series of reduced CO generation rates that allowed CPSC to assess benefits and costs of various levels of reduced emissions within technically feasible rates for each generator category.

The first part of the modeling study used the NIST multizone airflow and contaminant transport model CONTAM, which predicted CO levels in different areas of each structure, over a 24-hour period.

Determination of CO Emission Rates, Run Times, and Heat-Release Rates for Carbureted Generators

Staff determined CO emission rates, run times, and heat release rates for NIST to model for current, carbureted generators (baseline carbureted generators) based on data from EPA's non-road small spark-ignition engine (NRSI) certification data Web site and advertised power ratings and engine specifications for representative products. These baseline parameters are shown in Table 4, and an explanation of the basis for the parameters follows.

TABLE 4—MODELED CO EMISSION RATES, RUN TIMES, AND HEAT-RELEASE RATES FOR BASELINE CARBURETED GENERATORS

Generator category	Average weighted CO rate at 17% O_2 (g/hr)	Average run time (hrs)	Average heat rlease rate (kW)
Handheld	900	8	2
Class 1	1,800	9	6
Class 2 Single Cylinder	4,700	10	13
Class 2 Twin Cylinder	9,100	9	25

To determine values for CO emission rates, run times, and heat-release rates representative of current generators involved in the fatal incidents, staff considered the generators produced by six large generator manufacturers. All of these manufacturers are members of the Portable Generator Manufacturers Association (PGMA), and, as documented on PGMA's Web site, are the major manufacturers of portable generators sold in North America and a significant majority of the industry.'' [37] Staff used the manufacturers' reported product specifications for 31 generators ranging from 900 to 15,000 watts rated power and developed the representative parameters for each of these inputs based on the range of generators in each of the four categories in Table 4.

Staff used the engine specifications provided by the generator manufacturer to search the EPA's NRSI engine certification data Web site to find the published CO emission rate corresponding to each generator's engine. Staff then calculated the weighted CO emission rate (in g/hr) for each generator's engine, by multiplying the g/kW-hr rate by 46.7 percent of the maximum engine power (46.7 percent of the maximum engine power is the weighted average based on the EPA six-mode calculations).[38] Staff assumes that the typical load profile of a portable generator used by a consumer is that of the weighted profile. In addition, staff assumes the engine's weighted CO rate is that of the generator.

Considering that 95 percent of the generator-related CO fatalities in CPSC's databases occurred when the generator was operated in an enclosed space, it is important for modeling studies to consider the CO emission rate when a carbureted generator is operating in such enclosed space scenarios. Evidence supporting this view is seen in results of findings from generator tests conducted by NIST under a prior interagency agreement with CPSC.[39] NIST's tests, as well as subsequent staff testing, showed that the CO emission rate of current carbureted generators increases threefold as the oxygen drops from normal levels (approximately 20.9 percent oxygen) to approximately 17 to 18 percent oxygen when a generator is operated in an enclosed space, such as those reported in the incident data. Consequently, to reflect more accurately current carbureted generator operation under oxygen depletion conditions, staff's calculated weighted CO emission rate, when each generator is operated outdoors at normal oxygen, was multiplied by a factor of 3.

The generators' run time on a full tank of gas that was associated with 50 percent of the advertised rated load was used to determine the full-tank run time used in the modeling. Fifty percent load was used because, as stated above, 46.7 percent of the engine's maximum power represents the weighted load profile, which is nominally 50 percent. Staff generally used manufacturer's product specifications for run time at 50 percent load, and in a few cases, used engineering estimates to determine the run times. Staff chose to model run times based on a full tank of fuel as a conservative assumption, despite knowledge of scenarios where a generator was used to allow completion of a specific short-duration task, in temporary power outage situations where power was restored within a few hours before a full tank of fuel could be consumed, or in scenarios where the generator was still running when victims were found, had summoned help, and/or had removed themselves from the area.

Staff estimated heat-release rates for these generators based on the fuel-consumption rate at 50 percent load, the manufacturer's specification for the generator's tank capacity, a heat of combustion of gasoline of 42.5 MJ/kg, and an assumed conservative 35 percent thermal efficiency of the engine.

[37] *www.pgmaonline.com.*

[38] The engine manufacturer's CO emission rate reported in the EPA's exhaust emission certification Web site, in terms of grams per kilowatt-hour (g/kW-hr), is the sum of six weighted CO rates in grams per hour (g/hr) that the engine emits while installed on a dynamometer test platform and operating with each of six steady-state loads applied (also referred to as modes) divided by the sum of the weighted power for those six modes. The EPA's six-mode test cycle was developed with industry to replicate typical in-use operation of small utility engines when used in all types of engine-driven products.

[39] Emmerich, S.J., A. Persily, and L. Wang, *Modeling and Measuring the Effects of Portable Gasoline-Powered Generator Exhaust on Indoor Carbon Monoxide Level* (NIST Technical Note 1781), Feb 2013.

Determination of CO Emission Rates, Run Times, and Heat Release Rates, for Reduced Emission Rate Portable Generators

NIST used the same values for run times and heat-release rates for the reduced CO emission rates of each generator category as those used for current generators.[40] NIST modeled the rates of 50, 125, 250, 500, 1,000 and 2,000g/hr. The three lowest of these approximates the range of CO emission rates that staff believes are technically feasible for both the handheld and class 1 generator categories (50 g/hr), class 2 single-cylinder category (100 g/hr), and class 2 twin-cylinder category (200 g/hr) in ambient air with normal atmospheric oxygen.

Weather, Temperature and CO Rate Parameters for Carbureted and Reduced CO Emission Generators

Simulations were run for each model structure and model generator location for 28 representative weather days to determine the CO time course profiles, which are the minute-by-minute CO concentration levels in each of the various rooms of the house. The 28 weather days were chosen to include 14 cold weather days (Detroit, MI), seven weather days from warm months (Miami, FL) and seven transition months weather days (Columbus, OH) to represent the distribution of fatalities, which has been seen to skew towards cold-weather days in a similar manner.[41] Starting indoor temperatures were assumed to be 23 °C in all rooms, and temperatures were modeled to change within the rooms, based on heat transfer related to the heat release from the generator. Thus, generators of various sizes were modeled to be running on 28 different weather days for a full-tank run time[42] in various rooms within each of the structures, with run times and heat-release rates appropriate to that size of generator, and emissions based on current carbureted generators, or based on possible reduced-emission generators for comparison. In the modeling of baseline carbureted generators, to simulate the increasing CO emission rate as the oxygen level drops in the space the generator is operating (and thus, a lower CO emission rate at the beginning of operation than later), NIST modeled CO rates for the first 2 hours of operation that were only two-thirds of the rates shown in Table 4. After 2 hours, the CO rates were increased to the rates in Table 4 for the duration of the run time. In contrast, as another conservative assumption, NIST modeled *reduced* CO emission rates as constant rates for the entire respective generator run time. The results of the models provided CO time-course profiles for each room of each structure on each weather day for each generator type and location and emission rate.

3. Application of COHb Modeling

The second part of the modeling study used the CONTAM-generated CO time course profiles as input values to predict corresponding COHb levels expected in healthy adults, as a function of time, using Coburn Forster Kane (CFK) modeling.[43] Conservative assumptions were made about respiratory rates, given expected activity rates over the 24-hours of modeled exposure. The respiratory minute volume (RMV), expressed in liters per minute (L/min), is the specific inhalation rate input value used in the CFK, and for the epidemiological benefits calculated in this analysis, staff used an RMV of 10 L/min. Staff's use of a constant 10 L/min RMV for light activity likely overestimates the breathing rate (and CO uptake rate) of a significant number of victims. In the majority of fatal incidents, victims were at home during an unplanned power outage, or an outage due to utility shut off, and there was no indication that they had engaged in more than sedentary-to-light activity levels for most of the time. For example, in several of these cases, a generator was first started in an enclosed space late in the evening/night at a time where victims were clearly preparing for/or retired to bed; in these instances, a sedentary/resting activity level of 6 L/min RMV would be more appropriate. Thus, use of an RMV of 10 L/min is another conservative assumption in the analysis. This is explained in more detail in Tab K of staff's briefing package and its appendix.

To assess the impact of low-emission generators on potential reductions in CO fatalities, the number of observed fatalities from the incident data were assigned to one of the model structures. The initial step was to assign the fatalities that occurred in an ''exact match'' structure type. ''Exact match'' structures are defined as those that match all of the NIST structure characteristic parameters used in the analysis to describe the structure, such as floor area, number of floors, existence of a garage and/or basement. Where exact matches could not be assigned, fatalities were apportioned among best matching structure types (those matching the most number of NIST parameters).

These simulations included various generator location scenarios, dependent on house/structure model designs (*i.e.,* only models that had a basement included the generator-in-basement scenario; and only models that had an attached garage included the generator-in-the-attached garage scenario). To match, as closely as possible, actual usage patterns, the simulation results of the generator locations within the house/structure were proportionately equal to those observed in the incident data.

The victim's location in the modeled house is assumed to have equal probability of occurring in any living space room. This assumption was made for three reasons. In multi-fatality incidents, victims were often found in different locations within a house. In many cases, the victim's location could not be determined from available reports. Moreover, it was frequently unclear whether victims were located in a single area in which they were found for the entire time or if the individual moved around through various parts of the structure. An example of the latter case could be that an individual felt sick and moved, perhaps, to a bedroom to lie down before expiring.

Next, CPSC staff incorporated criteria that staff developed to evaluate modeled COHb profiles considered indicative of

[40] CPSC staff reasons that an additional weight and volume of the emission control components needed to reduce the CO emission rate, could be offset by a smaller fuel tank and due to the improved fuel efficiency of reduced emission engines, the smaller tank would still be able to maintain similar run times to carbureted units with larger fuel tanks.

[41] The 28 individual days were selected using historic weather data recorded at three different geographic locations and three different temperature ranges to approximate the distribution of incidents observed in the CPSC incident data at a generalized level. Although the weather days may be consecutive (*e.g.,* 14 consecutive cold weather days), there was no carry-over effect from one day to the next. Each day modeled was reset to zero CO. Therefore, each day, from a CO standpoint, was an independent event.

[42] NIST also modeled half-tank run times to simulate scenarios where shorter duration were considered more appropriate (*e.g.,* in scenarios in which the generator was being used to allow completion of a specific short-duration task at an unpowered location, in temporary power outage situations, where power was restored within a few hours before a full tank of fuel could be consumed, or in scenarios where the generator was still running when victims were found, had summoned help, and/or had removed themselves from the area). While staff has these modeling results, staff only analyzed the modeling results for the full-tank run times to estimate those benefits so as to be consistent with a conservative estimate of benefits.

[43] The CFK modeling is a nonlinear differential equation that is a physiologically based mechanistic model for predicting CO uptake and COHb formation and elimination in humans; it has been validated by empirical data from human studies and is widely regarded by authoritative sources as a reasonably reliable and broadly applicable COHb model for acute exposures.

fatal versus nonfatal outcomes. CPSC's Health Sciences (HS) staff developed four ''COHb Analysis Criteria'' to assess whether predicted COHb profiles from modeled residential scenarios were likely indicative of fatal or nonfatal CO exposures in average adults.[44] Where a fatal outcome is predicted, the criteria can be used to assess the predicted time to reach fatal exposure during a 24 hour modeling period for each simulated CO exposure. The criteria are intended to reflect the fact that lethal CO health effects are not simply a function of acute hypoxia resulting from a critical reduction in blood levels of oxygen delivered to tissues, as indicated by attainment of a specific peak COHb level.[45] The criteria include some consideration of the level and duration of the predicted COHb elevation, which recognizes that, in addition to reducing oxygen delivery to tissues, CO can enter the non-vascular body compartment and adversely impact important cellular functions by displacing oxygen from various intracellular heme proteins (particularly myoglobin proteins found predominantly in cardiac and skeletal muscles, and certain cytochrome P–450 enzymes involved is cellular respiration). In some prolonged CO elevations, the additional nonvascular adverse effects of CO can result in death at COHb levels that are not typically lethal.

Although the relationship is not absolute, physiological, epidemiological, and clinical studies provide evidence that acute CO poisoning effects in healthy adults tend to follow toxicological dose-response principles, and that risk of more serious adverse CO poisoning effects worsen progressively as blood levels of COHb increase.[46] However, it is clear that lethal CO exposures cannot be defined simply by attainment of a single COHb level. Staff used several information sources to develop COHb assessment criteria to facilitate calculation of benefits estimates predicted for generators with reduced CO emissions. A recent authoritative review of CO toxicity by the Agency for Toxic Substances and Disease Registry indicates that there is a high risk of lethal outcome once COHb levels have reached a critical window, which, for healthy individuals, is generally considered to lie between 40 percent and 60 percent COHb.[47] HS staff reviewed information on COHb levels of victims who experienced acute, generator-related CO poisoning; COHb levels documented in fatal CO poisoning cases reported to CPSC were compared with COHb levels reported for a select group of survivors who received hyperbaric oxygen treatment (HBO–T) for generator-related CO poisoning injuries considered to be of high severity. Staff also considered information on fatal and nonfatal COHb levels reported in non-fire-related CO poisoning cases that did not specifically involve generator-related CO exposures. Based on review of available data on COHb levels in fatal and nonfatal generator-related CO exposures, and other non-generator, non-fire related CO deaths and injuries, staff developed the following criteria to distinguish between modeled COHb levels indicative of lethal versus nonlethal outcome:

(1) If peak level is ≥60% COHb, assume death.

(2) If peak level is ≥50% COHb but <60%, assume death unless average duration of elevation >50% COHb is less than 2 hours, and average duration of elevation between ≥40% and <50% COHb is less than 4 hours.

(3) If peak level is ≥40% COHb, but <50% COHb, assume death if duration of the average in this range exceeds 6 hours.

(4) If peak level is ≤40% COHb, assume survival.

4. Determination of Deaths Averted

The final part of the modeling study used patterns evident in fatal incident data (such as the known percentages of deaths related to various generator locations for various generator sizes and structure types) to modulate the modeled COHb data to estimate the number of fatal CO exposures reported for each generator category that could have been averted at each reduced emission rate. The modeling included exposure duration of up to 24 hours, estimated on a minute-by-minute resolution, and determined the status of living versus dead for modeled occupants at each minute in time. The model assumed equal probabilities of intervention over a 24-hour period. This assumption was used because frequently, one could not determine from the incident data how long of an interval between when the generator was started and when the victim died or some other type of intervention occurred.

Although CPSC incident data reflect primarily fatal CO incidents, the assumption that surviving people eventually depart the exposure is supported by staff's estimates of at least 25,400 medically attended CO injuries involving generators over the period of the deaths modeled and the fact that in some fatal incidents, there were surviving victims. For each scenario (CO emission rate, structure model, generator location, occupied zone, weather day), the model produced estimated COHb levels. From these COHb levels, staff determined at each minute interval, whether the victim was dead or alive, based on the criteria outlined above. The average per-minute interval over the 28 days produced a probability of fatality at the given time. Under the assumption of equal probability of intervention over the 24-hour period, the average probability of fatality over the 24-hour period is the overall fatality rate for the given scenario. For the current carbureted generator model simulation, the probability was normalized (scaled up) to 100 percent of the allocated deaths because this is based on the actual incident data. The reduced emission rate simulation results were scaled up by the same factor to normalize the data. The difference between the allocated deaths per scenario and the number estimated for the reduced emission levels is the estimate of the deaths averted for the specified scenario. The summation of all the modeled scenarios (at a given emission level) represents an estimate of the potential deaths averted, if a reduced emission level generator had been in use in place of the current carbureted types. Thus, the same scenarios and assumptions were used for each generator size, generator location, structure, and weather day combination for current and reduced emissions generators so that the comparison was consistent and the assumptions would apply in the same way to current and reduced emissions.

Table 5 presents a summary of the number of deaths that potentially could have been averted over the 2004 to 2012 time span, if low-emission generators were used in place of the high CO output generators that were in use during this period. CPSC staff estimates that a total of 208 out of 503 deaths

[44] See Tab K and Tab K appendices of staff's briefing memorandum.

[45] Oxygen binding sites of hemoglobin molecules have more than 200-fold higher affinity for CO than for oxygen.

[46] For example, loss of consciousness is not generally expected in average adults if peak COHb levels remain below 20 percent, but becomes increasingly more likely as levels approach, and exceed, 40 percent COHb. (Note: Staff is referring to the acute COHb blood levels actually reached, or predicted by modeling, which is not necessarily the same as the highest measured COHb levels reported in clinical cases, where initial COHb measurements are typically reduced from peak levels attained, primarily due to the time lag between the end of CO exposure and blood sampling, plus use of supplemental oxygen during this interval).

[47] Agency for Toxic Substances and Disease Registry (ATSDR), (June 2012) Toxicological Profile for carbon monoxide (web link: *http://www.atsdr.cdc.gov/toxprofiles/tp201.pdf.*

could have been averted. CPSC staff realizes there is uncertainty associated with this estimate given the assumptions and estimations staff used in developing this estimate. However, CPSC staff used conservative values and believes the uncertainty in the estimate is within the range of the sensitivity analysis that staff performed on the effectiveness of the emission rates, as described in the preliminary regulatory analysis.

TABLE 5—SUMMARY OF POTENTIAL DEATHS AVERTED AT TECHNICALLY FEASIBLE CO EMISSION RATES IN REDUCED OXYGEN, 2004–2012

Generator category	CO emission rate * simulating generator operation in an enclosed space	Actual fatalities allocated by class	Potential deaths averted	Potential lives saved rate (%)
Handheld	150	3.7	1.7	46.6
Class 1	150	176.2	87.7	49.7
Class 2 Single Cylinder	300	321.3	117.9	36.7
Class 2 Twin Cylinder	600	1.8	0.3	17.2
Total	....	503.0	207.6 = ~208	41.3

* These rates are 3 times the technically feasible rates at normal ambient oxygen (~20.9%) to account for CO emission rate increase in reduced oxygen. To account for production variation the CO emission rates in the proposed requirements are 1.5 times the technically feasible rate in normal oxygen.

The numbers are based on the conservative assumption of CO emission rates tripling from technically feasible rates in normal oxygen for each generator category when operating in theorized oxygen depletion. Staff tripled the rates because staff determined that in reduced oxygen levels, the emission rates of generators that meet the technically feasible rates in ambient air may increase. This factor of 3 is based on testing of carbureted generators conducted by NIST [48] and CPSC staff.[49] However, test results from NIST [50] indicate that the EFI generator depleted the oxygen significantly less than the carbureted generator when tested in each matched pair identical test scenario. Furthermore, based on staff's testing of three generators with fuel-injected engines having different degrees of closed-loop operation, staff believes the factor of increase when the oxygen is 17 percent may be less than 3 for some generators that use closed-loop EFI.[51] Therefore, based on both of these issues, the factor of 3 could likely overstate the weighted CO emission rates for some EFI generators when operated indoors, and understate the reduction in deaths and injuries resulting from the proposed standard. Consequently, staff believes that the assumption of a threefold increase in the technically feasible rates in ambient oxygen is an appropriate assumption to model, conservatively, for generators operating in enclosed space. Thus, staff ultimately determined epidemiological benefits overall, based on emission rates of 150, 300, and 600 g/hr technically feasible rates, as shown in Table 5.

Staff expects that some additional, but unquantified deaths, could be averted in the remaining 24 percent of fatalities that were not modeled, especially in fatal incidents where a generator was operated outdoors, and/or, that had co-exposed survivors. Staff's epidemiological benefits analysis is contained in TAB K of the staff's briefing package.

VII. Relevant Existing Standards

A. Portable Generator Label

On January 4, 2007, the CPSC voted unanimously (2–0) to require manufacturers of portable generators to warn consumers of carbon monoxide (CO) hazards through a mandatory label containing performance and technical data related to the performance and safety of portable generators. The required warning label informs purchasers: ''Using a generator indoors CAN KILL YOU IN MINUTES''; ''Generator exhaust contains carbon monoxide. This is a poison you cannot see or smell''; ''NEVER use inside a home or garage, EVEN IF doors and windows are open''; ''Only use OUTSIDE and far away from windows, doors, and vents.'' The label also includes pictograms. The label requirement went into effect on May 14, 2007, and is required for any portable generator manufactured or imported after that date.[52] Although the Commission believes that the mandatory label for portable generators might prevent some incidents of CO poisoning and death, as discussed in more detail in Section VIII of this preamble, evidence suggests that labeling alone is not sufficient to address the CO poisoning hazard, and that performance requirements for portable generators are needed.

B. Voluntary Standards

Underwriters' Laboratories Inc. (UL) and the PGMA have each been accredited by the American National Standards Institute (ANSI) to develop a U.S. safety standard for portable generators. However, only PGMA has developed an ANSI standard for portable generators, ANSI/PMGA G300–2015. UL has also developed a standard, UL 2201, which has not become an ANSI standard, due to lack of consensus. International Organization for Standardization (ISO) 8528–13:2016, *Reciprocating Internal Combustion Engine Driven Alternating Current Generating Sets—Part 13: Safety,* is a standard applicable to portable generators sold overseas.

1. UL 2201

In 2002, UL formed a standards technical panel (STP) to develop the first voluntary standard in the United States, dedicated solely to portable generators, UL 2201 *Safety Standard for Portable Generator Assemblies.* CPSC technical staff joined the STP for UL 2201 at its inception and has been an active participant with a long record of

[48] Emmerich SJ, Polidoro, B, Dols WS. *Simulation of Residential CO Exposure Due to Indoor Portable Generator Operation,* NIST Technical Note 1925, 2016.

[49] See Tab J in the staff's briefing package.

[50] Buyer J. *Technology demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator.* U.S. Consumer Product Safety Commission, Bethesda, MD, September 2012.

[51] Tab J of staff's briefing package.

[52] 16 CFR part 1407.

advocating that the standard address CO poisonings.

The requirements in UL 2201 cover internal combustion engine-driven generators rated 15 kW or less, 250 V or less, which are provided only with receptacle outlets for the AC output circuits. The scope section of UL 2201 states that the standard addresses: ''the electric shock, fire, and casualty aspects associated with the mechanical performance and the electrical features of portable engine-driven generator assemblies.'' The standard restates the mandatory CPSC label requirement, but the standard does not otherwise address the risks related to CO poisoning. UL 2201 includes construction requirements to define minimum acceptability of components of the fuel system, engine, alternator, output wiring and devices, frame/enclosures and others, to ensure their suitability in this application to mitigate the risk of shock, fire and physical injury to users. The standard includes tests applicable to electrical, fire or mechanical hazards, as well as manufacturing tests.

UL has been unable to achieve consensus within the STP for UL 2201 to be recognized as an ANSI standard. Therefore UL 2201, first published in 2009, currently exists as a UL standard without ANSI recognition.

In January 2014, CPSC staff sent a letter to the UL 2201 STP Chair to request that a task group be formed to work on proposals to address the CO hazard that would eventually be balloted by the STP.[53] The letter outlined a framework of requirements based on work done by and for CPSC staff, which could be used as a starting point for discussions. This letter is described in more detail in the staff's briefing package. Accordingly, UL formed a task group with a roster of 37 members representing a broad range of stakeholder interests, including manufacturers of engines, generators, fuel-control systems and emission control components; public health officials; first responders; medical experts; indoor air quality experts; and government representatives from National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC), NIST, and CPSC staff. The task group chair is a representative from NIOSH. The first meeting of the task group was held in May 2014. As of August 2016, there have been 26 meetings, all held as teleconference meetings, and there has been active participation and constructive input from a number of the members, but the task group has not yet sent a proposal to the STP to consider for adoption into UL 2201. A more detailed description of this effort is provided in TAB I of the staff's briefing package.

The Commission is unaware of any portable generator that is, or has been, certified to UL 2201; as such, it is unlikely that there would be substantial compliance with the standard it if CO emissions requirements were incorporated.

2. ANSI/PGMA G300–2015

In 2011, PGMA was accredited by ANSI to be a standards development organization, allowing PGMA, in addition to UL, to develop a standard for portable generators. PGMA is the accredited standards development organization for ANSI PGMA G300—*Safety and Performance of Portable Generators.* CPSC staff served on PGMA's canvass committee. CPSC staff submitted comments to the standard, including comments regarding the lack of requirements in the standard to address the CO hazard.[54] PGMA published the first edition PGMA G300 as an American National Standard in June 2015.

PGMA G300 provides a method for testing the safety and performance of portable generators ''rated 15 kW or smaller; single phase; 300 V or lower; 60 hertz; gasoline, liquefied petroleum gas (LPG) and diesel engine driven portable generators intended for multiple use and intended to be moved, though not necessarily with wheels.'' PGMA G300 includes construction requirements for engines, fuel systems, frame/enclosures, alternators, and output wiring and devices. The standard includes safety tests intended to address electrical, fire or mechanical hazards during intended generator operation. It also includes a section on testing for determination of output power rating that it delineates as non-safety based. PGMA G300 also includes manufacturing tests to ensure minimum levels of safety for production units. Although the standard restates the mandatory CPSC label requirement for portable generators, it does not otherwise address the risks related to CO poisoning.

CPSC staff continues to work with PGMA and urge them to address the CO hazard.[55] CPSC staff participated in a PGMA technical summit on March 17, 2016, and reaffirmed this commitment.[56] In April 2016, PGMA informed staff that ''the PGMA Technical Committee will create a performance based standard that addresses the CO hazard created when portable generators are misused by operating them in or near occupied spaces as its top priority. The performance standard, once developed, will be proposed to the canvass group for addition to ANSI/PGMA G300 in the next revision cycle.'' [57] CPSC staff responded to PGMA [58] and met with PGMA again at PGMA's request in August [59] and September 2016.[60]

On September 19, 2016, PGMA emailed a letter to Chairman Kaye indicating that PGMA is in the process of re-opening G300 and announcing its intent to develop a ''performance strategy focused on CO concentrations.'' [61] In the letter to Chairman Kaye and in CPSC staff's September meeting with PGMA, PGMA described only broad generalities of a framework for modifying G300 that involves testing a generator in an

[53] Buyer, Janet, letter to Diana Pappas-Jordan, 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, January 14, 2014. *http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/Portable-Generators/CPSCstaffletterto ULdatedJan142014.pdf.*

[54] Buyer, Janet, letter to Joseph Harding, Subj: CPSC Staff Comments on BSR/PGMA G300–201x, *Safety and Performance of Portable Generators,* January 2, 2015. *http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/Portable-Generators/CPSCstaffletterto PGMAregardingG300draftstandarddated 122015.pdf;* Buyer, Janet, letter to Joseph Harding, Subj: CPSC Staff Comments on BSR/PGMA G300–201x, *Safety and Performance of Portable Generators* dated January 30, 2015, March 6, 2015. *http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/Portable-Generators/CPSC-staff-letter-to-PGMA-with-comments-on-draft-G300-standard.pdf.*

[55] Letter from PGMA to Joel Recht, dated April 20, 2016, available online at: *http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/Voluntary-Standards-Reports/PGMA LettertoRechtCPSCCooperationFinal.pdf.*

[56] CPSC staff presentation, *CPSC Staff Technical Research to Address the Carbon Monoxide Hazard for Portable Generators,* March 17, 2016.

[57] The Commission's understanding is that PGMA's revision cycle is every 5 years.

[58] Recht, Joel, Letter to Susan Orenga, Response to PGMA Letter to Joel Recht dated April 20, 2016, May 13, 2016. *http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/Portable-Generators/CPSCRechtLetterto PGMAMay132016inresponsetoPGMAletterdated April202016.pdf.*

[59] Smith, Timothy, Log of Meeting, CPSC Staff, PGMA, and Exponent, August 12, 2016, available online at: *https://www.cpsc.gov/s3fs-public/Meeting%20Log%20for%20meeting%20with%20 PGMA%202016-08-12_0.pdf.*

[60] Recht, Joel, Log of Meeting, CPSC Staff and PGMA, September 6, 2016, available online at: *https://www.cpsc.gov/s3fs-public/09%2006%2016 %20Meeting%20with%20PGMA%20Follow%20up %20on%20Technical%20Summit%20on%20 Carbon%20Monoxide%20Hazard%20Mitigation %20for%20Portable%20Generators.pdf.*

[61] Letter from PGMA to Chairman Elliot Kaye, dated September 16, 2016, available online at: *https://www.cpsc.gov/s3fs-public/PGMALtrChair KayeVoluntaryStandardFinal.pdf.*

enclosed space (test chamber).[62] The Commission looks forward to working with PGMA on developing a performance requirement addressing the CO poisoning hazard associated with portable generators. Given that PGMA described only broad generalities to CPSC regarding PGMA's intent to modify G300, the Commission does not have an adequate basis to determine if modifications to the voluntary standard would likely eliminate or reduce the risk of injury or death. In addition, because the Commission is unaware of any portable generator that is or has been certified to G300, it is unlikely there would be substantial compliance if CO emissions requirements were incorporated.

3. ISO 8528–13:2016

ISO 8528–13:2016 *Reciprocating Internal Combustion Engine Driven Alternating Current Generating Sets—Part 13: Safety,* is a standard applicable to portable generators sold overseas. Its requirements regarding the CO poisoning hazard are limited to labels and markings. It requires that the generating set must have a visible, legible, and indelible label that instructs the user: ''exhaust gas is poisonous, do not operate in an unventilated area.'' The standard also requires that the general safety information section of the instruction manual mention: ''Engine exhaust gases are toxic. Do not operate in unventilated rooms. When installed in ventilated rooms, additional requirements for fire and explosion shall be observed.''

C. Adequacy of the Voluntary Standards for Portable Generators in Addressing CO Deaths and Injuries

The Commission does not believe that any of the standards discussed in the previous section are adequate because they fail to address the risk of CO hazard beyond restating the CPSC mandatory labeling requirement and the Commission does not believe that the mandatory labeling requirements, alone, are sufficient to address the hazard. Additionally, the Commission is not aware of any firms certifying products to these standards. Thus, the Commission does not believe there is substantial compliance with the standards. Therefore, the Commission concludes that the voluntary standards are not adequate in addressing CO deaths and injuries.

[62] Product Safety Letter, *PGMA Talks Broad Strokes on Standards Work with CPSC,* Volume 45, Issue 34, September 12, 2016.

VIII. Response to Comments

In this section, we describe and respond to comments to the ANPR for portable generators. We present a summary of each of the commenter's topics, followed by the Commission's response. The Commission received 10 comments in response to the ANPR. Subsequently, in a two-part technology demonstration, CPSC contracted with UA to conduct a generator prototype development and durability demonstration program and contracted with NIST to conduct comparative testing of an unmodified carbureted generator and prototype generators in an attached garage of a test house facility. CPSC staff published a report regarding the results of the two-part technology demonstration program that included both the UA development and durability program and the NIST comparative testing program[63] and received 12 comments in response to this report. NIST published a report concerning its comparative testing of generators,[64] and staff received four comments in response to its report. The Commission responds to these comments, as well. The comments can be viewed on: *www.regulations.gov,* by searching under the docket number of the ANPR, CPSC–2006–0057.

A. Mandatory Carbon Monoxide Label

Comment: One commenter claimed that the CO hazard will continue to exist even if the Commission's demonstrated technology of the prototype 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 commenter claimed that, for this reason, the CPSC should ''conduct a study that includes a human factors analysis to determine the effectiveness of the CPSC mandated CO warning adopted in 2007.'' The commenter also encouraged CPSC to revise the mandated warning ''to incorporate the standards and format'' in ANSI Z535.3–2011, *American National Standard Criteria for Safety Symbols,* and Z535.4–2011, *American National Standard Product Safety Signs and Labels.*

Response: Although the Commission concurs with the commenter that the CO hazard associated with portable generators will continue to exist to some degree, even if CPSC's demonstrated technology were applied to commercially available generators, it does not necessarily follow that educating owners about the proper use of generators is, should be, or would remain, the first line of defense. Human factors and safety literature identify a classic hierarchy of approaches to control hazards, based primarily on the effectiveness of each approach in eliminating or reducing exposure to the hazard. The use of hazard communications such as warning labels is universally recognized as less effective than designing-out the hazard of the product or guarding the consumer from the hazard. Thus, hazard communications are lower in this ''hazard control hierarchy'' than these other two approaches.[65] Hazard communications are less effective because they do not prevent consumer exposure to the hazard; instead, they must persuade consumers, who see and understand the communication, to alter their behavior in some way to avoid the hazard. Thus, hazard communications should be thought of as ''last resort'' measures that supplement, rather than replace, product redesign or guarding efforts to address residual risks, unless these higher level hazard-control efforts are unfeasible.

The commenter recommends that CPSC conduct a study to determine the effectiveness of the CPSC-mandated CO warning. The commenter states that testing is needed because of the importance of ''educating owners about the proper use of their generators.'' Based on this assertion, the Commission infers that the commenter's measure of effectiveness is the extent to which the warning is understood by consumers, assuming the warning had initially captured and maintained the

[63] Buyer, Janet, *Technology Demonstration Of A Prototype Low Carbon Monoxide Emission Portable Generator,* September 2012. (available online at: *http://www.cpsc.gov/PageFiles/129846/portgen.pdf* and in *www.regulations.gov* in docket identification CPSC-2006-0057-0002.).

[64] Emmerich, S.J., A. Persily, and L. Wang, *Modeling and Measuring the Effects of Portable Gasoline Powered Generator Exhaust on Indoor Carbon Monoxide Level* (NIST Technical Note 1781), National Institute of Standards and Technology, Gaithersburg, MD, February 2013. (available online at: *http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Home/Portable-Generators/PortableGenerators041213.pdf.*

[65] Laughery, K.R., & Wogalter, M.S. (2011). The Hazard Control Hierarchy and its Utility in Safety Decisions about Consumer Products. In W. Karwowski, M.M. Soares, & N.A. Stanton (Eds.), *Human Factors and Ergonomics in Consumer Product Design: Uses and Applications* (pp. 33–39). Boca Raton, FL: CRC Press; Vredenburgh, A.G., & Zackowitz, I.B. (2005). Human Factors Issues to Be Considered by Product Liability Experts. In Y.I. Noy & W. Karwowski (Eds.), *Handbook of Human Factors in Litigation* (Chapter 26). Boca Raton, FL: CRC Press; Williams, D.J., & Noyes, J.M. (2011). Reducing the Risk to Consumers: Implications for Designing Safe Consumer Products. In W. Karwowski, M.M. Soares, & N.A. Stanton (Eds.), *Human Factors and Ergonomics in Consumer Product Design: Uses and Applications* (pp. 3–21). Boca Raton, FL: CRC Press.

consumers' attention. CPSC's mandatory labeling requirements for portable generators states that the product label shall be located on a part of the generator that is ''prominent and conspicuous to the operator,'' while performing at least two of the following operations: Filling the fuel tank, accessing the receptacle panel, and starting the engine.[66] The rule also requires that the label remain permanently affixed, intact, legible, and largely unfaded over the life of the product.[67] These requirements, as well as the minimum type size requirements,[68] were developed purposefully to address issues related to capturing and maintaining consumer attention and should address most concerns of this type, except for cases in which the user of the generator is not literate in English. However, the question of whether the label also should be provided in languages other than English was raised and addressed in detail in the final rule.[69] In summary: (1) Available generator-related incident data have revealed no pattern of incidents involving people who could not read English; (2) the overall positive impact of adding another language to a label is likely to be very small; and (3) the regulation does not prohibit the addition of another language version of the warning message to the mandatory label.

The Commission supports the testing of warnings and other hazard communications. However, as discussed in the preamble to the mandatory labeling final rule, an independent contractor already performed focus-group testing with low-literacy individuals on the product label initially proposed in the notice of proposed rulemaking (NPR), and the Commission revised the final label to address the message text comprehension problems identified during testing.[70] The Commission acknowledges that incremental improvements to the language of the label might be possible by conducting additional comprehension testing. However, the Commission also believes that the most significant label comprehension problems have already been addressed and that additional testing of this sort is unlikely to detect problems that would substantially impact comprehension among those at risk.[71] In terms of the formatting of the mandatory label, the Commission notes that the formatting and requirements of the mandatory generator label are virtually identical to the requirements of ANSI Z535.4–2011 and Z535.3–2011. Although the Commission acknowledges that the formatting of the mandatory label technically does not match the panel format requirements of ANSI Z535.4, these differences were deliberate and intended to improve warning comprehension. In addition, the Z535 series of standards includes exceptions and examples that are consistent with the formatting of the mandatory label. Revising the mandatory label to strictly meet the panel format requirements of Z535.4 is unlikely to improve the effectiveness of the label, and the Commission believes such changes actually could have a negative impact because it would separate the graphics from the relevant safety messages. Thus, the Commission believes that such revisions are neither appropriate, nor desirable.

B. Technical Requirements/ Specifications

1. *Comment:* Two commenters state that significant engine design changes would be required to incorporate and adapt emission technologies for use into any prototype portable generators. The commenters assert that engine designs that incorporate the prototype design changes are possible, but may not be suitable for all engines, especially when considering price and reliability considerations.

Response: To reduce the CO exhaust levels in portable generator units, staff developed the prototype generator with commercially available parts for better fuel delivery controls and exhaust emission controls. The prototype generator did not require extensive design changes. The prototype generator engine was derived from a readily available unit with a carburetor-equipped engine, which was retrofitted with sensors and components for electronic microprocessor controls of the intake manifold fuel injection and combustion spark timing. The prototype engine with electronic fuel controls required no disassembly between the engine cover, engine block, or cylinder head. Therefore, the head gasket and cylinder compression rings were left in their original condition. Considering price, staff agrees that there is an added cost to EFI engines, as discussed in the preliminary regulatory analysis. As to reliability, staff notes that the prototype generator was successfully tested for its longevity in service (durability) for 500 hours, which was the rated useful life, as established by the manufacturer.

Staff notes that the CPSC prototype generator was meant to be a durability program demonstration to support substantially reduced CO emission rates and encourage research on an approach to mitigate the risk of fatal and severe CO poisoning. The prototype portable generator was not intended to be a production unit, as manufacturers would need to consider appropriate suitable designs for their engine families in portable generators. Staff's prototype findings have since been repeated by others who patterned their reduced CO emissions prototype generators on the design concept developed for CPSC by the University of Alabama.[72]

2. *Comment:* The Truck and Engine Manufacturers Association (EMA) asserts that similar engine designs, including basic fuel-injection and ignition design are uniform across several manufacturers' product lines of gasoline-fueled engines, where possible. Products like lawn mowers and portable generators may use a similar engine design and components, and EMA states that this uniformity across many products provides manufacturing flexibility and economy of scale. EMA states the implementation of a different engine design in portable generators, such as described in the prototype program, may impact cost and availability of the product.

Response: The prototype design was specifically originated and developed through available off-the-shelf electronic fuel controller and components adapted onto an existing marketed portable generator engine. The prototype generator was successfully tested for its longevity in service (durability) for 500 hours, which were the longevity and emission outcomes of the new EFI engine through the rated useful life, as established by the manufacturer.

CPSC staff acknowledges the EMA concern that adoption of a portable generator engine, specifically designed to reduce CO emissions, may have

[66] 16 CFR 1407.3(a)(iii)(B).

[67] 16 CFR 1407.3(a)(iv).

[68] The signal word ''DANGER'' must be in letters not less than 0.15 inches and the remaining text must be in type whose uppercase letters are not less than 0.10 inches, or about 10-point type size.

[69] 72 FR 1443 (January 12, 2007).

[70] Id.

[71] Virzi, R.A. (1992). Refining the test phase of usability evaluation: How many subjects is enough? *Human Factors, 34*(4), 457–468, has found that about 80 percent of all usability problems tend to be detected with only four or five subjects; about 95 percent of all problems are detected with nine subjects; and each additional subject was less likely to detect new usability problems. The Commission believes that these general principles are likely to apply to comprehension testing as well, particularly in tests that oversample low-literacy individuals.

[72] See Techtronic Industries (TTi) presentation 3/17/16 at PGMA's Technical Summit on Carbon Monoxide Hazard Mitigation for Portable Generators—pages 85–105 of 178 page pdf file at: *http://www.cpsc.gov//Global/Newsroom/FOIA/Meeting%20Logs/2016/MeetingLogPGMA31716.pdf.*

different engine components pricing compared to the current portable generator engine without the emission reduction. CPSC staff notes that portable generators with EFI (though not specifically designed for low CO emissions) have been increasing in availability in the market as new models have been introduced.

3. *Comment:* Honda states that the photos of the prototype unit cylinder head in the University of Alabama report, *Prototype Low Carbon Monoxide Emission Portable Generator Build Description and Performance Evaluation,*[73] may indicate that combustion gases had been leaking to the outside because the head gasket was in the early stages of failure prior to the time that the engine was disassembled. Honda indicates that they made these findings based on the carbon deposits on the prototype cylinder head fin and head gasket seating surface, shown in the photos in Figure 22 of UA's report.

Response: The cylinder heads, pistons and several other components are photographed and compared in the post durability wear analysis section of Contractor University of Alabama's report, *Low Carbon Monoxide Emission Prototype Portable Generator Build Description and Performance Evaluation*. Figure 22 in UA's report shows a side-by-side comparison of the cylinder heads from the baseline generator (an unmodified unit) to the prototype generator unit after completion of the 500 hours of durability testing. CPSC staff partly agrees with the Honda photo assessment because more carbon deposits are visible on the prototype cylinder head gasket surface, compared to the same component in the baseline. However, the prototype's head gasket endured approximately 585 engine hours of the durability program and subsequent emission testing. According to UA's report, the head gasket with the baseline unit leaked after 175 engine hours into the durability test and was replaced. The cylinder head photos, which compared the generator units after completion of the durability test, showing less carbon deposit on the baseline engine's cylinder head gasket seating surface may be explained by fewer accumulated engine hours on the newer head gasket. Furthermore, staff notes that the prototype engine had been run for 585 hours by the time the photograph was taken, which was 85 hours beyond the manufacturer's rated useful life of the engine.

4. *Comment:* Honda states that that the increased combustion temperature due to the prototype's stoichiometric air-to-fuel mixture and reliance on radiant cooling is insufficient, as evident in the condition of photographed engine components, such as the pistons, after completion of the durability test.

Response: CPSC staff agrees with Honda that leaner fuel ratios generally result in increases in combustion temperatures. Increasing the air-to-fuel ratio available for combustion was intentional in the prototype engine, to influence and reduce the CO mass flow in the exhaust emission. Cylinder head temperatures were measured in generator units at all various load profiles for each occurrence of emission testing. These emission tests occurred before modifications to engine or durability testing, during the durability testing, in which hours of engine operation were accumulated, and after the durability tests.

Emission and engine test data were collected on the as-received, carburetor-fueled generators units. According to the University of Alabama report, *Low Carbon Monoxide Emission Prototype Portable Generator Build Description and Performance Evaluation,* the as-received generator unit selected to become the prototype, but not yet modified, measured a 13.98 AFR at full generator loading (mode 1), with an associated 227 °C cylinder head temperature. In addition, the range of AFR values for this pre-modified prototype generator measured 13.98–11.26, with progressively richer AFRs toward idle or no-load. The maximum cylinder head temperatures with the stoichiometric EFI after prototype engine modification were no hotter than the original unit. Staff believes that the 14.0 AFR carburetor design offered no cylinder head cooling capacity over the stoichiometric EFI design. Throughout the prototype generator program, including independent laboratory dynamometer emission testing after 500-cyclic engine hours of operation, the engine demonstrated a cylinder head temperature less than 227 °C at full load. The mid-to-no load operating temperatures were cooler. All of these recorded measurements of the prototype cylinder head temperatures, including full load, were well below the manufacturer-recommended temperature limits.

Another comparison of cylinder head temperatures involves the baseline generator, which remained unmodified as the original unit, and the prototype generator. According to the *Low Carbon Monoxide Emission Prototype Portable Generator Build Description and Performance Evaluation* report, the carburetor fuel system of the baseline generator delivered 13.4 to 10.5 AFR values for the range of generator loads throughout the durability program. Similar to the pre-modified prototype generator, progressively richer AFRs occurred in the baseline generator towards idle or no-load. Alternatively, the prototype generator fuel strategy sought to maintain the same stoichiometric AFR across all loads. These differences in AFR values created an average elevated temperature of 28 °C in the prototype unit to the baseline unit. Staff believes the 28 °C average hotter temperatures across all loads created more discoloration in the prototype piston. There appears to be more blackened areas of the piston ring, and more coloring below the seated position of the piston ring indicate hotter operating temperatures in the prototype cylinder compared to the baseline unit. However, as mentioned, the recorded measurements of the prototype cylinder head temperatures, including full load, were well below the manufacturer recommended temperature limits. For the technology demonstration program, the prototype's leaner AFR to minimize CO exhaust production was believed to be balanced with higher, but acceptable, cylinder temperatures.

5. *Comment:* EMA states that greater CO emission levels occurred with the prototype portable generator at 500 hour end-of-life compared to zero hour, suggesting that some deterioration of the prototype engine occurred with accumulation of engine hours.

Response: The UA report contains an appendix with prototype and baseline generator engine-hour durability emission test results for low-, high- and mid-life engine hours. This appendix shows prototype portable generator post-catalyst CO emission results at 2 g/kW-hr near 0 engine-hours and 17.5 g/kW-hr at 500 engine-hours. Staff does not believe that these results reflect deterioration, but rather, a mid-load controller calibration performance issue, which surfaced primarily in the post-durability emission tests.

This 500-hour prototype emission test performance was due to portions of the fuel look-up tables[74] that were not

[73] UA's report (Puzinauskas, P, Dantuluri, R, Haskew, T, Smelser, J, . Prototype *Low Carbon Monoxide Emission Portable Generator Build Description and Performance Evaluation,,* The University of Alabama, Tuscaloosa, AL, July 2011) is available as TAB G in the staff report referenced previously (Buyer, Janet, *Technology Demonstration Of A Prototype Low Carbon Monoxide Emission Portable Generator,* September 2012.)

[74] The fuel look-up tables are part of the electronic programming of the Engine Control Unit

calibrated in the initiation of the engine build. Initially, it was not known that rated engine speeds supporting an alternator would involve extensive variation. Therefore, only certain areas of the controller look-up tables were mapped. Retrospectively, it is known that the mode 4 or mid-load solution was simply to expand the same parameters throughout the ECU look-up tables and all engine speeds. In the final emission tests, larger AFR excursions and higher CO emissions occurred when the engine operated in the unmapped portions of the controller. While the post durability prototype generator CO emissions results show more than 90 percent reduction over the baseline unit, the emission reduction with the prototype could likely be reduced further with more comprehensive calibration of the controller.

6. *Comment:* Honda states that the CPSC testing did not evaluate engine and generator performance in transient load conditions of performance.

Response: The empirical testing in the NIST test house included transient loads. NIST Technical Note 1781,[i] *Modeling and Measuring the Effects of Portable Gasoline Powered Generator Exhaust on Indoor Carbon Monoxide Level,* describes how NIST evaluated the performance of both the prototype and baseline unmodified generators in the garage, with several electrical loading variations, including the generator cyclic load profile in the durability program and emission testing.[75] The measuring test equipment at the NIST test house continuously collects CO measurements as the electrical and engine load profile was altered. The proposed performance requirement is based on measuring emissions while the generator is operating with a steady load applied, as opposed to a transient load.

7. *Comment:* Two commenters asserted that CPSC's prototype components may cause exacerbated reliability issues after long-term storage.

Response: Staff disagrees because fuel-injection improves reliability. A fuel-injected system is sealed, so the fuel is not exposed to air like the vented system associated with a carburetor. Exposure to air significantly contributes to degrading gasoline during long-term storage and, in turn, causes problems with starting and running the engine. Manufacturers advertise improved reliability as one of the benefits associated with fuel injection.

Comment: One commenter asserted that it is harder to apply EFI and catalyst on the smaller engines used in 1 kW–3 kW units and that they are sold in higher numbers than 5 kW units. In a similar comment, another commenter noted that CPSC's prototype used a commercial-grade engine in open frame, yet closed-frame units are more popular.

Response: CPSC has observed that there are fuel-injected handheld Class I engines, with and without catalysts, in the marketplace. CPSC acknowledges, however, that there may be more challenges associated with implementing the emission control technology on these smaller engines and the generators that these engines power. Thus, there is a later compliance date in the proposed rule for these models, relative to the larger generators powered by Class II engines. Based on CPSC staff's analysis of the market data, CPSC concurs that smaller generators are becoming more popular, relative to larger generators. CPSC staff used a larger generator, powered by a class II, single-cylinder engine, in the technology demonstration program because the Commission's incident data show that generators with these engines were associated with almost two-thirds of the CO deaths involving generators that have been reported to CPSC, when the size of the generator was identified, for the years from 2004 through 2012. The lower proposed performance requirements for smaller generators are expected to reduce deaths that could otherwise be expected to occur with increasing popularity of these smaller units.

8. *Comment:* One commenter stated that stable engine operation under transient loads requires richer-than-stoichiometric AFR. Without it, the commenter asserted, there is unreliable operation, which can result in damaged electrical loads and warranty claims.

Response: The Commission acknowledges this operating challenge, and for this reason, the proposed performance requirement is based on measuring emissions while the generator is operating with a steady load applied, as opposed to a transient load.

9. *Comment:* One commenter noted that their company uses more severe modes and requirements to test product durability, which they are doubtful the prototype would have survived. In a related comment, a commenter asserted that significantly reduced CO emissions at the highest loads resulting from operation near stoichiometric fuel control will negatively impact engine durability.

Response: The Commission notes that the proposed performance requirement for generators powered by class II single-cylinder engines is nominally six times higher (less stringent) than the CO rate that the prototype generator achieved. The Commission believes that the proposed CO emission requirements can be achieved on many existing engines by replacing the carburetor with closed-loop EFI and integrating a catalyst without engine design modification and without negatively impacting engine durability. The Commission notes, however, that for some engines, modifications might be needed to enable operation closer to stoichiometry. For other engines that cannot be improved through design modifications, those could still be used in generator applications by using a product integration strategy that precludes installed engine operation at loads where fuel enrichment is needed.

10. *Comment:* One commenter stated that the performance standard for CO emission rates must take into account deterioration of emissions to achieve the target exposure over the life of the engine.

Response: The Commission took deterioration into account in developing the performance requirements. The Commission believes deterioration of CO emissions to be minimal. This is based on both the performance of CPSC's durability-tested prototype at end of life as measured by CES, as well as by observation of published deterioration factors for CO, which are measures of the increase in CO emissions for an aged engine, relative to its emissions when new. The Commission observed in the EPA's exhaust emission database for model year 2015 that a vast majority of the engines have a deterioration factor below 1.1 (thus indicating the emissions worsen by less than 10 percent above initial emissions).

11. *Comment:* One commenter stated that the target CO emission rate in terms of g/kW-hr should be based on engine displacement, with lower rates (in terms of g/kW-hr) for larger engines to achieve the same target exposure.

Response: The Commission believes lower CO emission rates are technically feasible for smaller engines, compared to larger engines. Consequently, the Commission is proposing performance requirements for four different size

(ECU) of the EFI system. The tables are used to associate engine operating parameters measured by the system's sensors with how much fuel the injectors need to deliver to the combustion chamber in order for the EFI system to maintain the desired air/fuel mixture.

[75] Emmerich, S. J., A. Persily, and L. Wang, *Modeling and Measuring the Effects of Portable Gasoline Powered Generator Exhaust on Indoor Carbon Monoxide Level* (NIST Technical Note 1781), National Institute of Standards and Technology, Gaithersburg, MD, February 2013 (available online at: *http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Home/Portable-Generators/PortableGenerators041213.pdf* and in: *www.regultations.gov* in docket identification CPSC–2006–0057–0005.)

categories of generators that are each based on technical feasibility and analysis of benefits and costs as a function of engine displacement, and, for the largest category, also whether the engine has one or two cylinders. The epidemiological benefits considered exposure differences for different generator types, by allocating known incidents based on location of generator and location of victims in various house types.

12. *Comment:* One commenter asserted that reducing CO emissions will increase other pollutant emissions and risk of fire and burn hazard.

Response: The Commission does not agree that reducing CO emissions will increase other pollutant emissions. Based on the emission results from CPSC's prototype generator, as well as those from the EPA's demonstration program, reducing CO emission rates also results in reduced $HC+NO_X$ emissions. CPSC staff acknowledges that for CPSC's prototype, the leaner air fuel ratio resulted in elevated exhaust temperatures compared to the carbureted configuration. Staff notes, however, that the muffler that was used was chosen to easily accommodate integration of the small catalyst into it. This muffler had less internal baffling, which resulted in average muffler surface temperatures of approximately 70°C hotter than the OEM design. As a result, UA shrouded this muffler and that resulted in shroud surface temperatures that were lower than the OEM muffler that was not shrouded. Staff notes that use of better designed mufflers, and, if needed, improved flow of cooling air over the exhaust, could mitigate the effect of elevated exhaust temperatures.

13. *Comment:* One commenter stated that EFI systems are becoming more low cost and noted that an oxygen sensor of one particular design can serve as a safety switch if the engine starts operating rich of stoichiometric.

Response: The Commission has observed that small SI engines with EFI have entered the marketplace in recent years, and expects this would mean that they have become less expensive. The Commission is interested in combining reduced CO emissions with a mechanism that will shut off a generator when operated in an enclosed or semi-enclosed space.

14. *Comment:* One commenter stated that the results from testing the generators in NIST's garage should not be relied upon for any rulemaking related to portable generator safety because, the commenter asserted, the attached garage on NIST's test house is not sufficiently representative of how garages are conventionally constructed.

Response: The Commission used the results from NIST's test house to provide an example of the reduction in the house's hypothetical occupants' exposure that the reduced CO emission rate from a portable generator can yield when compared to a current carbureted generator when operated in the same garage. The Commission is basing the proposed performance requirements for the rule on technically feasible CO emission rates, along with an assessment of the impact of those rates through indoor air quality modeling of 40 structures, representative of the U.S. housing stock, where generators were operated in 503 of the deaths in CPSC's databases that occurred from 2004 through 2012.

15. *Comment:* Several commenters expressed concern about CO deaths caused by generators and expressed support for reducing generators' CO emission rates and their belief in the technical feasibility to do so.

Response: The Commission agrees with the commenters.

C. CO Poisoning Effects

1. *Comment:* The commenter considers that CPSC staff assumes COHb levels below 10 percent are not harmful. The commenter notes that there is no scientific basis for such an assumption and also notes that, in many studies, COHb levels do not correlate consistently with symptoms.

Response: The Commission does not assume that a CO exposure resulting in less than 10 percent COHb is incapable of causing adverse health effects. The Commission has long recognized the existence of populations especially sensitive to CO health effects (fetuses, asthmatics, and individuals with cardiovascular diseases). Most authorities, including CPSC, consider individuals with coronary artery disease [CAD] to be the population most sensitive to potential adverse health effects of CO at the lowest exposure levels. Some studies report individuals with CAD might perceive adverse health effects, and/or, tests show that they may experience adverse health effects that they are unaware of, at about 2 percent to 5 percent COHb. The Commission understands that the pathophysiological effects of CO are complex and strongly influenced by multiple factors, particularly CO level, exposure duration, and exposed individual's inhalation rate and health status. In the ANPR on portable generators, and in the prototype report documents, CPSC focused on extremely high-level, acutely lethal, CO exposures caused by generator exhaust. Therefore, rather than provide an exhaustive review of all studies, including equivocal findings in some low-level exposure studies, CPSC is providing an overview of the complex interactions between multiple variables that influence the end effects of acute, high-severity CO exposures in humans. CPSC emphasizes that CO poisoning effects should be understood to be a continuum of effects of the exposure, rather than be viewed as discrete health effects tightly tied to specific CO levels or COHb levels.

2. *Comment:* One commenter stated that although a low CO emissions generator would undoubtedly save lives if widely applied, ''prediction of confusion and incapacitation from COHb levels is not possible.'' The commenter cited his recent publication reporting that ''symptoms of CO poisoning do not correlate well with COHb levels.'' Based on his findings and other clinical reports, the commenter questions the validity and/or concept of a table relating COHb levels to particular symptoms, as used by the Commission. The commenter believes that it is incorrect to use COHb levels to calculate egress times from a CO-containing environment and notes that there are no data to support the method. Another commenter also questioned the validity of an approximate relationship between COHb levels and severity of CO poisoning symptoms and health effects.

Response: The Commission's use of predicted COHb levels was not intended to calculate an actual egress time from a CO exposure, and the Commission noted that reduced emission generators would not guarantee egress by exposed individuals. Rather, the Commission considers that reduced generator CO emissions, as achieved with its prototype unit, will substantially delay the rate at which CO levels rise in poorly ventilated spaces, and will thus delay the rate at which COHb levels of exposed individuals rise (in some cases reducing the peak COHb level attained). This will provide significantly increased time available for individuals to remove themselves from the exposure environment or to be rescued by an outside party. Supporting evidence that some individuals will react appropriately to slower onset of CO poisoning effects has been reported (*e.g.,* 111 of 167 patients with CO poisoning presented to Florida hospital emergency departments (ED) between 5 a.m. and 10 a.m., after waking and feeling ill consequent to overnight use of a generator during hurricane-related power outages). CPSC data indicate that in 69 of 93 cases where it was known how and why a patient with generator-related CO exposure presented to an ED, the patient had either transported themselves or contacted others (9–1–1, family, friends) to arrange for their transport to the ED. In the remaining cases, individuals were found in distress by others (either a lesser affected co-exposed individual or an outside party).

The Commission recognizes that even healthy individuals can exhibit variability in individual susceptibility to CO health effects under identical exposure scenarios. The Commission understands that, in clinical situations, CO poisoning symptoms and health effects do not necessarily correlate well with a patient's initial COHb measurement, which is often confounded (generally reduced by factors such as time interval relative to cessation of CO exposure and provision of supplemental oxygen). Clearly, COHb measurements can be of limited value to physicians when determining appropriate treatment plans for individual patients. Rather than make clinical decisions, the Commission needed to provide controlled, systematic comparisons of how CPSC's reduced CO emissions prototype generator could be expected to reduce the lethal CO hazard presented by the unmodified original generator. Therefore, CPSC used identical physiological input parameters for a healthy adult to model COHb formation and elimination from empirical generator CO time course exposure data. CPSC used predicted times taken to rise to, and progress through, three convenience benchmark percentile COHb values to compare the relative CO poisoning hazard presented by a generator before and after design modifications to reduce its CO emission rate. The Commission considered these benchmark values to approximate relatively mild (20% COHb), potentially incapacitating (40% COHb), and likely lethal (60% COHb) exposure levels. Although indicating health effects generally first reported at these benchmark COHb levels, CPSC did not intend to convey that they represented precise measures when appearance of symptoms and adverse health effects would be expected in all individuals. CPSC noted that rapidly rising, high-level CO exposures of several thousand ppm (as can occur with current carbureted generators) would result in extreme oxygen deprivation and fast-rising COHb levels, causing rapid incapacitation, loss of consciousness and death, without individuals necessarily experiencing milder, progressively worsening CO poisoning symptoms typically manifested in slowly rising or lower-level CO exposures.

As further detailed in the staff's briefing package, the available physiological research data and clinical findings in the scientific literature support the use of ''COHb benchmarks,'' for approximate estimation and comparison of CO-related health effects expected during generator-related exposures.[76] The Commission welcomes suggestions on alternative health-based approaches to compare the reduced CO emissions generators with current products in terms of improved safety benefits.

D. Jurisdiction

Comment: One commenter asserted that pursuant to § 31 of the CPSA, the CPSC lacks authority to regulate the risk of injury associated with CO emissions from portable generators because that risk could be addressed under the Clean Air Act (CAA). Specifically, the commenters rely on Section 213 of the CAA, which directs the EPA to conduct a study of emissions from non-road engines to determine if they cause or contribute to air pollution, ''which may reasonably be anticipated to endanger public health or welfare.'' 42 U.S.C. 7547(a)(1)(2006). Under this provision of the CAA, the EPA has promulgated regulations governing CO emissions from portable generators. In particular, 40 CFR part 90 imposes requirements to control emissions from non-road spark-ignition engines, which includes portable generators, at or below 19 kilowatts.

Response: Section 31 of the CPSA does not establish an absolute prohibition to CPSC action whenever the CAA is implicated. Rather, the Commission lacks authority to regulate a risk of injury associated with a consumer product if that risk ''could be eliminated or reduced to a sufficient extent through actions'' taken under the CAA. 15 U.S.C. 2080(a). Case law and the legislative history of § 31 confirm this. *See ASG Industries, Inc.* v. *Consumer Product Safety Comm'n,* 593 F.2d 1323 (D.C. Cir. 1979) (under section 31, CPSC is to consider all aspects of the risk and make a judgment whether the alternate statute can sufficiently reduce the risk of injury).

The legislative history indicates that Congress contemplated a stricter ban on the CPSC's jurisdiction and rejected it. Specifically, the Senate version of the bill for § 31 would have precluded CPSC's jurisdiction if the product was ''subject to safety regulations'' under one of the statutes listed in section 31 of the CPSA. S. Rep. No. 92–749, 92d Cong., 2d Sess. 12–13 (1972). In contrast, as the *ASG* court noted, under the House version of the bill, which was eventually enacted, the Commission has authority if there has not been sufficient reduction or elimination of the risk of injury. H.R. Rep. No. 92–1593, 92d Cong., 2d Sess. 38 (1972).

The CAA and the EPA regulations promulgated under it that address CO emissions from portable generators have not sufficiently reduced or eliminated the risk of CO poisoning associated with portable generators that the CPSC seeks to address. Deaths and injuries associated with CO emissions from portable generators have increased since the EPA adopted its regulations limiting CO emissions from the type of engines used in portable generators.

The CAA and the EPA's regulations create national standards intended to address large-scale ambient air pollution, not acute CO exposure from portable generators. The CAA and the EPA's regulations, created under 42 U.S.C. 7407, are designed to reduce CO emissions in regional areas that exceed National Ambient Air Quality Standards. These requirements are not designed to reduce the localized risk to consumers from acute CO poisoning when portable generators are used in the home.

Additionally, EPA's 2008 adoption of an averaging program for CO emissions from marine engines further demonstrates that its regulations are not concerned with the risk of acute CO poisoning, but only large-scale overall emission levels. This averaging program allows a manufacturer to exceed the EPA's CO emission limits for a group of similar engines, as long as the manufacturer offsets that increase with another ''engine family'' with emission levels below the EPA's limit. 73 FR 59,034 (Oct. 8, 2008). It is noteworthy that this averaging program applies to CO emissions from marine engines, which the EPA explicitly acknowledges are associated with ''a substantial number of CO poisonings and deaths.'' 73 FR 59,034, 59,048 (Oct. 8, 2008). Under this program, emissions from an individual engine are inconsequential to EPA's rule, and so is the individual consumer's exposure level. Rather, the EPA's determination of CO emission limits focuses on ambient air pollution on a large scale.

Finally, the structure of the CAA and its delegations of authority make the EPA unable to adequately address the risk of injury associated with CO poisoning to consumers from portable

[76] Tab K, Appendices, of staff's briefing package.

generators. Under the CAA, the EPA sets National Ambient Air Quality Standards (NAAQS) and has oversight and enforcement authority, but the states retain primary responsibility for ensuring air quality. Section 107 of the CAA sets out states' responsibilities for ensuring air quality, including determining how the state will meet NAAQS, and identifying attainment and non-attainment areas. 42 U.S.C. 7407. The U.S. Supreme Court has emphasized that the EPA is ''relegated by the [CAA] to a secondary role,'' as long as states adopt plans that meet the general requirements. *Train* v. *Natural Resources Defense Council, Inc.,* 421 U.S. 60 (1975). This broad leeway provided to states indicates that the CAA and the EPA's regulations are not intended to and cannot provide sufficient specificity to mitigate the risk of CO poisoning.

E. CO Sensor Systems and Exhaust Pipe Extension

1. Generator-Mounted CO Sensing Shutoff Systems

Comment: Four comments were submitted on the concept of a generator-mounted safety shutoff system using CO sensing technologies that could be used to limit consumer exposure to CO present in portable generator exhaust. Three of the four commenters advocated for such a system, and one advocated against it.

One comment in support of the use of residential CO alarm technology noted that a CO sensor that is used to activate ventilation systems in parking garages can be used for turning off the generator when it senses 35 ppm CO. The Commenter also recommended that the system be interlocked to prevent generator operation every 2 to 3 years, when the sensor's useful life is expended, and to prevent operation, if the user disables the system.

The commenter who did not recommend the use of residential CO alarm technology expressed the belief that COS sensing technology near a generator may impair its operation, causing users to disconnect the sensors to ensure a steady source of electricity. The Commenter also noted that CO sensors require routine maintenance, and their capabilities can degrade with time and during extended periods of inactivity, adding that it may be unreasonable to expect consumers to regularly check and maintain the CO sensing equipment, particularly when the generator is not even being used.

Response: The Commission shares the concern that using CO sensing technology in the vicinity of a portable generator may impair the generator's operation, causing users to disconnect the sensors. The Commission agrees that it is unreasonable to expect consumers to regularly check and maintain CO sensing equipment, particularly when a generator is not being used. Early in the portable generator project, the Commission investigated one version of the concept of an on-board CO sensing shutoff system; the investigation and its findings are documented in the staff report, *Phase 2 Test Report: Portable Generator Equipped with a Safety Shutoff Device* (Brown, 2013). Its goals were to: (1) Determine if a CO sensor/alarm output signal from commercially available residential CO alarms (meeting the requirements in UL 2034 *Single and Multiple Carbon Monoxide Alarms*), when retrofitted with circuitry connected to the generator, could trigger a shutoff device installed on a portable generator when the CO alarm activated; and (2) measure CO concentrations around the generator when operated in multiple environments to assess CO migration and levels that might occur under several scenarios. Test environments examined included outdoors, in a two-sided structure, as well as inside and under a temporary modular storage (TMS) building.

In that investigation, the Commission found that when the generator was operated inside the TMS building, the CO migrated and accumulated on the far side of the room more quickly than near the generator. The CO alarms on the generator never activated before those located elsewhere in the space activated, with the time difference generally ranging from 5 to 10 minutes. In some tests, CO levels in some parts of the room reached up to 1,000 ppm before the CO alarm on the generator activated and shut off the generator. When the generator was operated in wide-open outdoors in a light breeze condition, CO concentrations ranging up to 350 ppm were measured in the immediate vicinity of the generator. Although this did not activate the CO alarms mounted on the generator to shut it off, the Commission believes this could occur in some circumstances. This would detrimentally affect the utility of the generator when used in a proper location.

In addition to these performance deficiencies, the Commission is concerned about the ability of CO sensors to survive the environments produced by an operating generator. Currently available electrochemical and semiconductor CO sensors, which dominate the CO sensing market, have numerous vulnerabilities that will compromise their ability to maintain accuracy if they are used in an atmosphere containing high concentrations of hydrocarbons, as is present in a generator's exhaust, particularly when used in a confined space.

Regarding one commenter's recommendation to use CO sensors that turn on ventilation fans in parking garages, a recent energy efficiency study examining the performance of parking garages that have CO-sensing activated ventilation indicates that this type of system is subject to failure if not maintained on the manufacturer's recommended schedule (California Utilities Statewide Codes and Standards Team, 2011). Systems employing both electrochemical and solid state technology that were five and 12 years old, respectively, failed likely because they had not been calibrated. A properly maintained 2-year-old electrochemical sensor-equipped system performed well. The commenter suggested that to account for the referenced 2 to 3 year expected sensor life, the consumer replace the sensor at the end of the sensor's useful life. The Commission believes that it is not appropriate for consumers to be required to replace a primary safety device, let alone replace it every 2 to 3 years, when the life of the overall product is much longer. Furthermore, making the sensor replaceable makes it vulnerable to tampering. Notwithstanding the previously mentioned CO concentrations that CPSC measured around a generator operating in a proper location, the conflict between making the sensor consumer-replaceable and tamper-proof leads the Commission to conclude that currently available sensors are not likely to be effective, given the long service life of portable generators. With respect to the recommendation for a 35 ppm CO set point for an on-board sensor, CPSC measured CO concentrations in excess of 35 ppm in the immediate vicinity of the generator, while operating outdoors within 11 minutes after starting the generator (Fig C2 in Brown, 2013). A 35 ppm limit for shutoff would greatly limit the utility of portable generators when used properly.

2. Remotely Located CO-Sensing Shutoff Systems

Comment: Two commenters raised concerns about the concept of a remotely located CO-sensing shutoff system, such as that investigated and documented in the staff report, ''*Demonstration of a Remote Carbon Monoxide Sensing Automatic Shut-Off Device for Portable Generators*'' (Lee, 2006). Conceptually, a remotely located

CO-sensing shutoff system would use a CO sensor located indoors to monitor for CO infiltration at that location and when it detects an unsafe CO concentration there, the sensing shut-off device would communicate with the generator to shut it off. The report presents CPSC staff's investigation of one version of such a concept, consisting of a CO alarm retrofitted with a wireless transmitter, placed by the user in an indoor location, which communicated with a wireless receiver mounted onto a portable generator operating in an attached garage. When the CO alarm activated, it energized a circuit on the generator and shut off the generator.

One commenter raised a number of behavioral and technical issues on the utility of such a system. This commenter noted that the same technical comments he made on the generator-mounted safety shutoff concept, discussed above, apply to the remote-sensing concept as well. This commenter also noted that remote-sensing technologies require consumers to take affirmative actions to properly locate sensors inside buildings and to monitor them to make sure that they continue to be operational. The commenter stated that the risk of the CO poisoning hazard would not be mitigated when consumers fail to locate or use the sensing technology properly or the detector malfunctions due to infrequent use or lack of maintenance.

Another commenter enumerated a number of concerns about the concept of a remote CO-shutoff system that included:

- Sensor performance affected by ambient conditions
- battery life
- the ability of consumers to install
- nuisance trips causing consumers to disable system
- the need to maintain proper battery charge
- ability of consumer to start generator, then remove the remote sensor to an area without CO, to allow the generator to operate.

Regarding the staff report, the commenter objected that only one model generator was included in the tests and that only a limited number of hazard scenarios were tested. The commenter provided a list of options that would need to be investigated to document remote CO-sensing device acceptability. The options include: (1) Effectiveness of the mandatory warning label; (2) effects of environmental conditions on CO dispersion in a building; (3) effect of generator load profile on CO dispersion; (4) effect of walls and building materials on the sensor's radio frequency (RF) signal to the generator; and (5) maximum distance between sensor/transmitter and the generator. Additional areas the commenter listed include: (6) Consumer's ability to reset the system in adverse conditions (darkness, storms); (7) timing of product sales (pre- or post-storm); (8) minimum component performance requirements; and (9) minimum battery requirements.

Response: The Commission agrees that there are multiple challenges with a remote CO-shutoff concept for portable generators, including many of the challenges identified by the commenters and notes that the staff report concluded with the following:

The study was limited to proof-of-concept and did not consider issues such as life expectancy, reliability, usability, and environmental conditions. All of these factors would need to be considered in developing a remote CO detection/shut-off system for portable generators for consumer use.

In addition to having the same sensor-related concerns as those stated above in CPSC's response to the on-board CO sensing shutoff concept, CPSC has additional concerns, a primary one being that a system of this sort would need to be provided with the generator and would require the consumer to properly install the sensing devices. The consumer could easily defeat the features by operating the generator in an enclosed location and intentionally placing the sensor outdoors or other locations away from where the CO is infiltrating in order to keep the generator running. Another scenario of concern involves the user placing the CO sensor in a room where he/she thinks the CO will infiltrate, but the CO infiltrates faster in another room that the system is not monitoring. Transmitter range is another concern; if a consumer properly locates the generator outdoors at a distance far enough from the dwelling to prevent CO infiltration, the distance may render the generator inoperable if it is not within range of the sensor signal. Based on the concerns mentioned above, the Commission is not pursuing this concept as a means of reducing the CO hazard associated with portable generators.

3. Flexible Exhaust Pipe Extension

Comment: One commenter recommended using an exhaust hose that has one end that fits over the tailpipe and a laterally expandable window fitting on the other end to direct exhaust out through a window. The commenter recommended that the hose should have an electrical circuit wired through its entire length, which plugs into the generator to prevent operation if the hose is not properly attached.

Response: There are several drawbacks to this approach. First, if the hose must be attached for the generator to operate, then it must be attached even if the generator is correctly located away from the house. CPSC believes this is not practical. Second, the CPSC database includes fatal CO incidents where the generator was located outside the dwelling, but not so far away to prevent exhaust from entering the home through leaks or openings (Hnatov, 2015). Third, CPSC staff believes that it is unlikely that an expandable window insert can be installed in such a way as to be leak tight. Last, this system's successful use depends on the consumer's ability to properly install both the hose and the window fitting. Given these concerns, the hose extension is not a technically feasible approach to address the carbon monoxide poisoning hazard associated with engine-driven portable generators.

F. Economic Considerations

On February 12, 2007, counsel for American Honda Motor Co., Inc., Briggs & Stratton Company, and Yamaha Motor Corporation, USA (the companies), submitted comments jointly on the December 12, 2006 advance notice of proposed rulemaking (ANPR), concerning portable generators. The companies made the following comments on economic issues:

1. *Comment:* The vast majority of consumers use their portable generators properly and safely. CPSC should give proper weight to the benefits and widespread uses of portable generators, as well as the affordability of current models.

Response: Although the great majority of consumers might exercise proper safety precautions, improper use of the product can and does have disastrous consequences. The Commission evaluated different technologies to address the risk and has concluded that a performance standard that sets requirements that reduce CO emissions from generators is the most reliable regulatory alternative to address the risks of CO poisoning associated with portable generators. Manufacturing cost increases under the proposed rule would generally have a relatively greater impact on percentage price increases (and consumer demand) for low-price units, such as units lacking inverter technology (as discussed in the preliminary regulatory analysis section). However, the analysis finds that the estimated benefits outweigh the costs to comply with the proposed rule.

2. *Comment:* Staff has not provided consumer exposure data to support risk analysis of CO deaths associated with consumer use of generators.

Response: Since the comment was filed, additional information and analysis has greatly improved the analysis of risks associated with consumer use of portable generators. The Commission's preliminary regulatory analysis has analyzed historical shipment information acquired from market research firms (Power Systems Research and Synovate), from federal data sources (the International Trade Commission and Bureau of the Census), and from individual manufacturers to estimate the numbers of portable generators in use, by engine class and other characteristics, during the period covered by CPSC staff's epidemiological benefits analysis (Hnatov, Inkster & Buyer, 2016). The new information and analysis has enabled CPSC to estimate CO poisoning risks (and societal costs) per generator in use. Additional information on product sales and use, which the industry is encouraged to provide in comments to this NPR, could further refine these estimates.

3. *Comment:* In response to the technology demonstration report, one commenter stated that although engine designs that incorporate the report's design changes [77] are possible, they may not be suitable for all engines, including many used 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.

Response: As noted, we agree that some types of generators (and engines) will be more severely affected by a proposed rule that is performance based, but is likely to be addressed by manufacturers through the use of EFI and catalysts (although some generators with handheld engines might not require catalysts) in terms of relative price increases that would result from incorporation of the technologies. The impact on demand for these products could affect their future availability to consumers.

IX. Description of the Proposed Rule

A. Scope, Purpose, and Compliance Dates—§ 1241.1

The proposed standard would apply to ''portable generators'' powered by small handheld and non-handheld SI engines, and would include requirements intended to limit carbon monoxide emission rates from these portable generators. The requirements are intended to reduce an unreasonable risk of injury associated with portable generators.

Generators within the scope of the proposed rule provide receptacle outlets for AC output circuits and are intended to be moved, although not necessarily with wheels. Products that would not be covered by the proposed rule include permanently installed stationary generators, 50 hertz generators, marine generators, generators installed in recreational vehicles, generators intended to be pulled by vehicles, generators intended to be mounted in truck beds, and generators that are part of welding machines.[78] Generators powered by compression-ignition (CI) engines fueled by diesel also are excluded from the scope of the proposed rule.[79]

The requirements would apply to four categories of portable generators: (1) Handheld generators; (2) class 1 generators; (3) class 2 single-cylinder generators; and (4) class 2 twin-cylinder generators. Handheld engines have total engine displacement of 80 cubic centimeters (cc) or less; non-handheld engines include EPA Class I engines, which have total engine displacement of less than 225cc, and Class II engines, which have displacement of 225cc and more. Class II engines have an upper limit determined by rated engine power, 19 kilowatts (kW), which is equivalent to 25 horsepower. Although the Commission categorized generators by the EPA classification of the engines powering them, it is important to distinguish these engines from the portable generators in which they are used because the engines are used in other products as well. To provide a clear distinction, the Commission refers to engines according to EPA's classification: Handheld engines, non-handheld Class I engines and non-handheld Class II engines, while referring to portable generators according to the Commission's definitions, handheld generators, class 1 generators, class 2 single-cylinder generators and class 2 twin-cylinder generators.

Under the CPSA, the effective date for a consumer product safety standard must not exceed 180 days from the date the final rule is published, unless the Commission finds, for good cause, that a later effective date is in the public interest. To meet the proposed performance requirements, it is likely that engines will need closed-loop fuel-injection, and with the exception of some handheld engines, the addition of a catalyst. Implementing closed-loop EFI and catalyst integration on all class II (single- and twin-cylinder) engines powering generators may require design modifications, such as redesign of cooling fins and a fan, to accommodate fuel control closer to stoichiometry. The Commission believes 180 days may not be adequate time to allow for such design modifications, and is instead proposing an effective date of 1 year following publication of the final rule, at which time portable generators with Class II single- and twin-cylinder engines, or class 2 single- and twin-cylinder portable generators, would be required to comply with the applicable requirements of the rule. The Commission proposes a compliance date of 3 years after publication of the final rule for generators powered by Class I engines and handheld generators, or class 1 and handheld generators. This later compliance date is to address manufacturers' concerns that, while industry has gained some limited experience with incorporating fuel injection on handheld and Class I engines, there may be different challenges associated with accommodating the necessary emission control technologies on these smaller engines. In addition, later compliance dates potentially could reduce the impact on manufacturers of generators, including small manufacturers, by providing them with more time to develop engines that would meet the requirements of the proposed rule, or, in the case of small manufacturers that do not manufacture the engines used in their generators, by providing them with additional time to find a supplier for compliant engines so that their generator production would not be interrupted.

[77] Mr. Gault is referring to the incorporation of an electronic control unit, manifold air pressure sensor, fuel pump, fuel injector . . . exhaust oxygen sensor, catalyst aftertreatment and other components used on the prototype generator.

[78] Stationary generators, marine generators, and generators installed in recreational vehicles are excluded because they are not portable. Generators intended to be pulled by vehicles, intended to be mounted in truck beds, generators that are part of welding machines, and 50-hertz generators are excluded because they are not typically used by consumers.

[79] CI engines are not typically used by consumers. In addition, CI engines have relatively low CO emission rates. The current EPA standard for CO emissions from CI engines rated below 8 kW is 8.0 g.kW-hr, which is significantly lower than the EPA standard of 610 g/kW-hr applicable to small SI engine classes used in portable generators.

B. Definitions—§ 1241.2

The proposed standard would provide that the definitions in section 3 of the Consumer Product Safety Act (15 U.S.C. 2051) apply. In addition, the proposed standard would include the following definitions:

(a) *handheld generator* means a generator powered by a spark-ignited (SI) engine with displacement of 80 cc or less.

(b) *class 1 generator* means a generator powered by an SI engine with displacement greater than 80 cc but less than 225 cc.

(c) *class 2 single-cylinder generator* means a generator powered by an SI engine with one cylinder having displacement of 225 cc or greater, up to a maximum engine power of 25 kW.

(d) c*lass 2 two-cylinder generator* means a generator powered by an SI engine with two cylinders having a total displacement of 225 cc or greater, up to a maximum engine power of 25 kW.

C. Requirements—§ 1241.3

1. Description of Requirements

The proposed rule would require that portable generators powered by handheld engines and Class I engines, or handheld and class 1 generators, not exceed a weighted CO at a weighted rate more than 75 grams per hour (g/h); generators powered by one-cylinder Class II engines, or class 2 generators, must not exceed a weighted CO emission rate of 150 g/h; and generators powered by Class II engines with two cylinders, or class 2 twin-cylinder generators, not exceed a weighted CO emission rate of 300 g/h. The weighted emission rates are based on weighting of six modes of generator operation, ranging from maximum generator load capability (mode 1) to no load (mode 6), similar to a procedure used by EPA to certify compliance with its emission standards for small SI engines.

2. Rationale

The proposed rule would impose different limits on weighted CO emission rates for different categories of generators in recognition of the effects of factors such as engine size and other engine characteristics on CO emissions, in addition to the different challenges that may be faced in meeting CO emission rates expressed in grams per hour. The proposed rule would apply different criteria to generators, based on EPA's classification of engines (and on the number of engine cylinders), rather than on power ratings of either the generators or the engines. This determination was based mainly on the absence of standard methods for defining the rated power, maximum power, or surge power of generators. Furthermore, staff determined that the technically feasible emission rates were different for different categories of generators. Staff also found differences in hazard patterns for different categories; this is reflected in the determination of epidemiological benefits (for example more fatalities associated with large generators involved their use in garages as opposed to basements, while for small generators the reverse was true, as described in detail in staff's briefing package in Tab K).

The requirements of the proposed rule are based on technically feasible emission rates and an analysis of the benefits and costs associated with these technically feasible emission rates. The benefits analysis and cost analysis are explained in detail in Section VI and Section X, respectively, of this preamble.

D. Test Procedures—§ 1241.4

The proposed rule details the test procedure that the Commission would use to determine compliance with the standard, but also provides that any test procedure that will accurately determine the emission level of the portable generator may be used.

The procedure the Commission would use is largely based on a test method that was developed in a collaborative effort with industry stakeholders and is explained in greater detail in Tab J of the briefing package. In brief, the Commission intends to perform the tests in ambient temperature in the range of 10–38 °C (50–100 °F) using E10 gasoline. The six loads that will be applied to the generator for determining the weighted CO emission rate are based on the generator's maximum load capability. Maximum load capability is determined by increasing the load applied to the generator to the maximum observed power output, without causing the voltage or frequency to deviate by more than 10 percent of the nameplate rated voltage and 5 percent of the nameplate rated frequency and can be maintained for 45 minutes with stable oil temperature. The loads will be applied using a resistive load bank capable of achieving each specified load condition to within 5 percent and will be measured using a power meter with an accuracy of ± 5 percent. The Commission will use constant volume sampling (CVS) emissions measurement equipment, as described in the EPA's regulations 40 CFR part 1054 and 40 CFR part 1065 as of 2016. If the generator is equipped with an economy mode or similar feature that has the engine operating in low speed when not loaded, the setting that produces the highest weighted CO emission rate will be used to verify whether the applicable carbon monoxide emissions rate is met.

E. Prohibited Stockpiling—§ 1241.5

In accordance with Section 9 of the CPSA, the proposed rule contains a provision that prohibits a manufacturer from ''stockpiling'' or substantially increasing the manufacture or importation of noncomplying generators between the date of the final rule and its effective date (or compliance date, in the case of generators with handheld and Class I engines). The rule would prohibit the manufacture or importation of noncomplying portable generators by engine class in any period of 12 consecutive months between the date of the promulgation of the rule and the effective/compliance date at a rate that is greater than 125 percent of the rate at which they manufactured or imported portable generators with engines of the same class during the base period for the manufacturer. The base period is any period of 365 consecutive days, chosen by the manufacturer or importer, in the 5-year period immediately preceding the promulgation of the final rule.

Generator sales can vary substantially from year to year, depending upon factors such as widespread power outages caused by hurricanes and winter storms. Annual unit shipment and import data obtained by CPSC staff show that it has not been uncommon for shipments to have varied by 40 percent or more from year to year at least once in recent years. The 5 year period in the anti-stockpiling provision is intended to allow manufacturers and importers sufficient flexibility to meet normal changes in demand that may occur in the period between the promulgation of a rule and its effective/compliance date while limiting their ability to stockpile noncomplying generators for sale after that date. Allowing manufacturers to produce noncomplying generators in amounts that total 125 percent of their peak 365-day period over the prior 5 years could give manufacturers enough flexibility to respond to demand if there is a year of major power outages that create a demand for consumers to purchase portable generators. The Commission is aware of some large manufacturers that have seen year-to-year shipments increase by 50 percent and 70%, so the Commission believes that the allowable stockpiling percentage over a base period should be greater for generators than most other consumer products. The Commission seeks comments on the proposed product manufacture or import limits and the base period.

F. Findings—§ 1241.6

In accordance with the requirements of the CPSA, we are proposing to make the findings stated in section 9 of the CPSA. The proposed findings are discussed in section XVI of this preamble.

X. Preliminary Regulatory Analysis

The Commission is proposing to issue a rule under sections 7 and 9 of the CPSA. The CPSA requires that the Commission prepare a preliminary regulatory analysis and that the preliminary regulatory analysis be published with the text of the proposed rule. 15 U.S.C. 2058(c). The following discussion is extracted from staff's memorandum, ''Draft Proposed Rule Establishing Safety Standard for Portable Generators: Preliminary Regulatory Analysis.''

A. Introduction

The CPSC is issuing a proposed rule for portable generators. This rulemaking proceeding was initiated by an ANPR published in the **Federal Register** on December 12, 2006. The proposed rule includes weighted carbon monoxide emission limits from four different categories of portable generators.

Following is a preliminary regulatory analysis of the proposed rule, including a description of the potential costs and potential benefits.

B. CPSC Staff Assessment of the Adequacy of Voluntary Standards for Portable Generators in Addressing CO Deaths and Injuries

As indicated in Section VII.B of this preamble, two organizations, Underwriters' Laboratories, Inc. (UL), and the Portable Generator Manufacturers Association (PGMA), have been accredited by the American National Standards Institute (ANSI) to develop U.S. safety standards for portable generators. Although each organization has developed a standard (designated as UL 2201 and PGMA G300, respectively), only PGMA's standard has achieved the consensus needed to be recognized by ANSI (as ANSI/PGMA G300–2015). A UL 2201 task group has been working on developing proposals to address CO hazards of portable generators; however, the task group has not yet sent a proposal to the standards technical panel established by UL to consider for adoption into UL 2201. The current version of UL 2201 includes the mandatory CPSC label, but does not otherwise address the risks related to CO poisoning. In the Commission's view, the label alone is insufficient to address the risk of injury from CO poisoning. CPSC is unaware of any portable generator that has been certified to UL 2201. Therefore, it is unlikely whether there would be substantial compliance with UL 2201 if the standard were to incorporate CO emissions requirements (Buyer, 2016b).

PGMA G300 also includes the mandatory CPSC label for portable generators, but it does not otherwise address the risks related to CO poisoning. In a letter emailed to Chairman Kaye on September 19, 2016, PGMA announced its intention to reopen G300 to develop a ''performance strategy focused on CO concentrations.'' As discussed in Section VII.B of this preamble, the Commission does not have an adequate basis to determine that PGMA's modification to G300 would likely eliminate or reduce the risk of injury or that there likely will be substantial compliance with the voluntary standard, once modified. In addition, based on the complex nature of setting CO limits and the fact that G300 is just now being re-opened, the Commission is not convinced that a modification to the voluntary standard adequately addressing the risk of injury identified in the rulemaking would be accomplished within a reasonable period of time. CPSC believes that significant technical work, requiring significant time, would be required to develop appropriate requirements and test methods within the broad framework identified in the PGMA letter [80] and at a September 6, 2016, public meeting between PGMA and staff.[81] Specifically, as discussed at the meeting and in the NPR briefing memorandum, there are several technical concerns about shutoff criteria and testing that would need to be investigated (Buyer, 2016a). The Commission is concerned whether the test methodologies would be accurate, dependable and practicable and sufficient to ensure that the generators would shut off quickly enough in a sufficient number of common scenarios seen in portable generator incidents to result in an adequate reduction in the risk of injury and death. The Commission expects that significant periods of time will be needed to evaluate each of these factors. For example, determining the expected epidemiological benefits for the proposed rule required nearly a year for NIST to conduct a modeling study and for staff to evaluate the study. For the PGMA to develop an effective voluntary standard, similar efforts will be required to assess the standard after the technical details have been established.

[80] *https://www.cpsc.gov/s3fs-public/PGMALtrChairKayeVoluntaryStandardFinal.pdf.*

[81] *https://www.cpsc.gov/s3fs-public/09%2006%2016%20Meeting%20with%20PGMA%20Follow%20up%20on%20Technical%20Summit%20on%20Carbon%20Monoxide%20Hazard%20Mitigation%20for%20Portable%20Generators.pdf.*

C. Market Information

1. Manufacturers

Based on data obtained from Power Systems Research, Inc. (''PSR''), a total of 78 domestic or foreign manufacturers produced or exported gasoline-powered portable generators for the U.S. market in recent years. However, most of these manufacturers were based in other countries. The Commission has identified 20 domestic manufacturers of gasoline-powered portable generators, 13 of which would be considered small businesses based on the Small Business Administration (''SBA'') size guidelines for North American Industry Classification System (''NAICS'') category 335312 (Motor and Generator Manufacturing), which categorizes manufacturers as small if they have fewer than 1,250 employees.

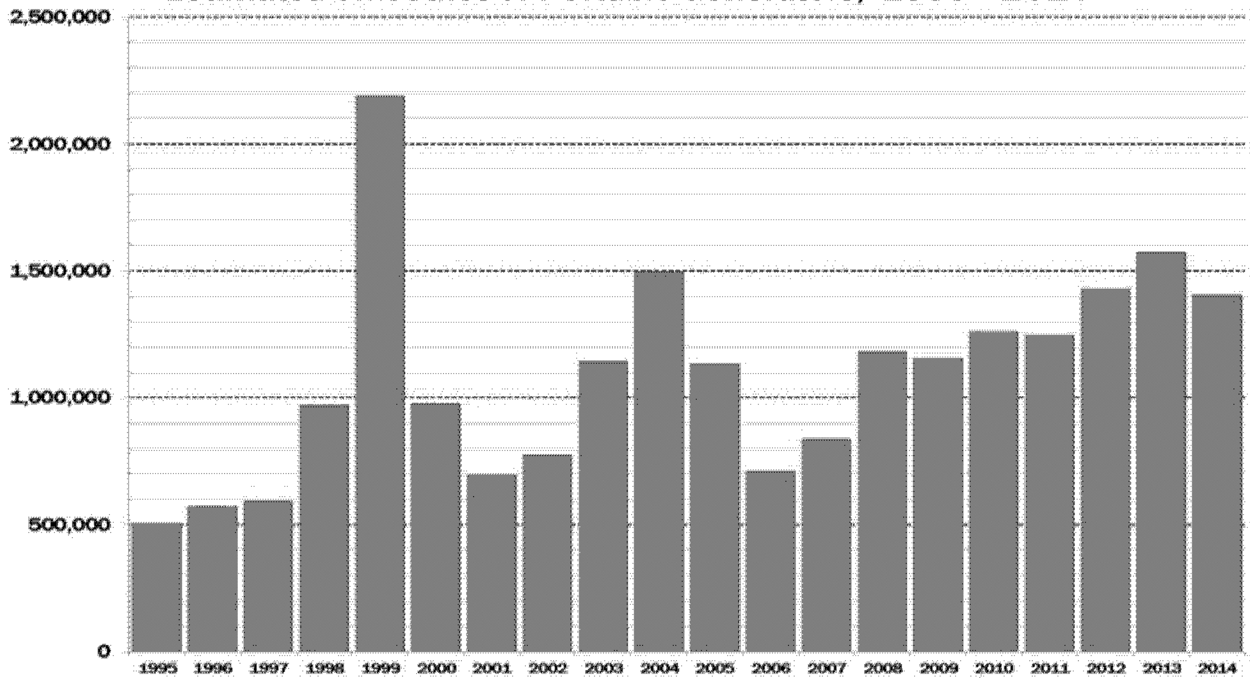
Few of the 78 firms involved in production for the U.S. market in recent years have held significant market shares: Less than half of these firms have reportedly had annual shipments of 1,000 units of more, and only six firms have had annual shipments of 50,000 units or more. From 2009 through 2013, the top five manufacturers combined for an estimated 62 percent of the U.S. market for portable generators with power ranges more likely to be in consumer use and the top 10 manufacturers combined for about 84 percent of unit sales during that period. Under the CPSA, firms that import generators from foreign producers would be considered manufacturers of the products. A review of import records for portable generators found that the annual number of individual importers of record has ranged from about 25 to 30 in recent years. These firms would be responsible for certifying that the products they import comply with the rule, should it be finalized by the Commission.

2. Annual Shipments/Sales of Portable Generators

CPSC Directorate for Economic Analysis staff acquired information on annual unit sales of portable generators through contract purchases from market research firms, from federal data sources (*e.g.,* the International Trade Commission [ITC] and Bureau of the

Census), and other sources.[82] Chart 1 presents information on sales of portable generators for 1995 through 2014. Sales estimates are based on estimated portable generator shipments and projected shipments to U.S. retailers for the years 1998–2002 and 2007–2013 (RTI International, 2006;[83] Power Systems Research, 2012, 2013);[84] and estimated U.S. consumer purchases of portable generators for 1995–1997 and 2004–2008 (Synovate, 1999, 2006, 2009).

Chart 1.
Estimated Unit Sales of Portable Generators, 1995 – 2014



As shown by the chart, consumer demand for portable generators from year to year fluctuates with power outages, such as those caused by hurricanes and other storms along the Gulf and Atlantic coasts and by winter storms in other areas. Periods of increased demand for portable generators may be followed by reduced demand because a larger percentage of households had made recent purchases. Evidence of the importance of weather-related power outages in driving demand for portable generators was highlighted in the fiscal 2007 annual report issued by Briggs & Stratton, a leading manufacturer of engines used in the production of generators (its own and others). The report, noted that for 2007, the company had ''a 66% reduction of engine shipments for portable generators caused by a lack of events, such as hurricanes, that cause power outages'' (Briggs & Stratton, 2007). Additionally, spurred by widespread concerns over the possible impact of Y2K in disrupting power supplies, estimated portable generator shipments rose to about 2.2 million in 1999, still the highest year for estimated sales (RTI, 2006).

3. Product Characteristics of Portable Generators Shipped in Recent Years

Power Ratings

Data obtained by the Commission in recent years show that portable generators purchased by consumers and in household use generally range from under 1 kW of rated power up to perhaps 15 kW of rated power. The Commission believes that the most powerful portable generators are mainly purchased for construction or commercial use, although some also end up in household use.[86] In Table 6, we present information on generator power ratings for shipments of portable generators powered by Class I or Class II engines for the U.S. market for the years 2010 through 2014, based on Commission analysis of data obtained from PSR, import data from the U.S. International Trade Commission, and information provided by individual firms. The generators are separated into six power-rating categories. Over this 5-year period for shipments, about 6.9 million gasoline-powered portable generators were shipped for consumer use, or an average of about 1.4 million units per year. Shipments of nearly 1.6

[82] Power Systems Research, compiled information on domestic production and imports of portable generators from its OE Link™ market intelligence database of original equipment and original equipment manufacturer (OEM) production & forecast data. Synovate (which was purchased by another market research firm, Ipsos, in 2011), based on analysis of surveys of the firm's Continuing Consumer Survey panel and the firm's Multi-Client Research Group (SMRG) sample.

[83] RTI International (2006, October), Industry Profile for Small Nonroad Spark-Ignition Engines and Equipment—revised draft report. Authored by Alex Rogozhin, William White & Brooks Depro.

[84] Power Systems Research, Inc. (2012, 2013), Excel data file: OE Link™ original equipment database, portable generator sets produced and sold in the United States, Attached to email from Marilyn Tarbet, PSR, to Charles Smith, Directorate for Economic Analysis, CPSC, October 3, 2012, Excel data file: OE Link™ original equipment production—forecast database with sales data, portable generators produced outside of the United States, sold in the United States, Attached to email from Marilyn Tarbet, PSR, to Charles Smith, Directorate for Economic Anaylsis, CPSC, October 4, 2013.

[86] Although generator power ratings are only known for about 48 percent of the units involved in death reports as of May 21, 2015, for the period of 2004 through 2012, fewer than 3 percent of these units had power ratings of 8 kW or greater, and the most powerful unit involved was 10 kW (Hnatov. 2014).

million units in 2013, made 2013 the peak year for sales during this period.

Data on recent portable generator shipments, as shown in Table 6, compared to information on consumer purchases before 2010, indicate that the U.S. market has shifted toward smaller, less powerful units. Synovate surveys on generators purchased by consumers from 2004 to 2006, found that about 9 percent of units likely purchased for consumer use (< 15kW) had continuous electrical outputs of under 2 kW and about 12 percent had ratings of 2–3.49 kW (Synovate, 2008). Data acquired from PSR and individual manufacturers on portable generator shipments in more recent years show that units with power ratings of under 2 kW comprised an estimated 21 percent of the market, and units with power ratings of 2–3.49 kW have held an estimated market share of about 36 percent over 2010 to 2014 (as shown in Table 6). The market share of larger units, with outputs of 6.5 kW or more, fell from about 22 percent of the market in 2004 to 2006, to about 9 percent over 2010 to 2014.[87]

Table 6.
Shipments of Portable Generators, 2004—2006 & 2010—2014, by Rated Generator Power, in Kilowatts (kW)

Generator kW Range	2004 — 2006 Annual Average	2010 — 2014 Annual Average
Under 2 kW	100,900	283,923
percent	9.1%	20.5%
2 to 3.49 kW	136,245	496,684
percent	12.2%	35.9%
3.5 to 4.99 kW	196,552	184,874
percent	17.6%	13.4%
5 to 6.49 kW	437,669	289,669
percent	39.3%	20.9%
6.5 to 7.99 kW	142,277	46,938
percent	12.8%	3.4%
8 kW & Greater*	100,893	81,808
percent	9.1%	5.9%
All Portable Generators	1,114,536	1,383,896

Source: Power Systems Research, Inc. data; market estimates for individual firms; analysis by Directorate for Economic Analysis, CPSC.

* Limited to generators powered by Class II engines (*i.e.*, under 19 kW).

Engine Classes

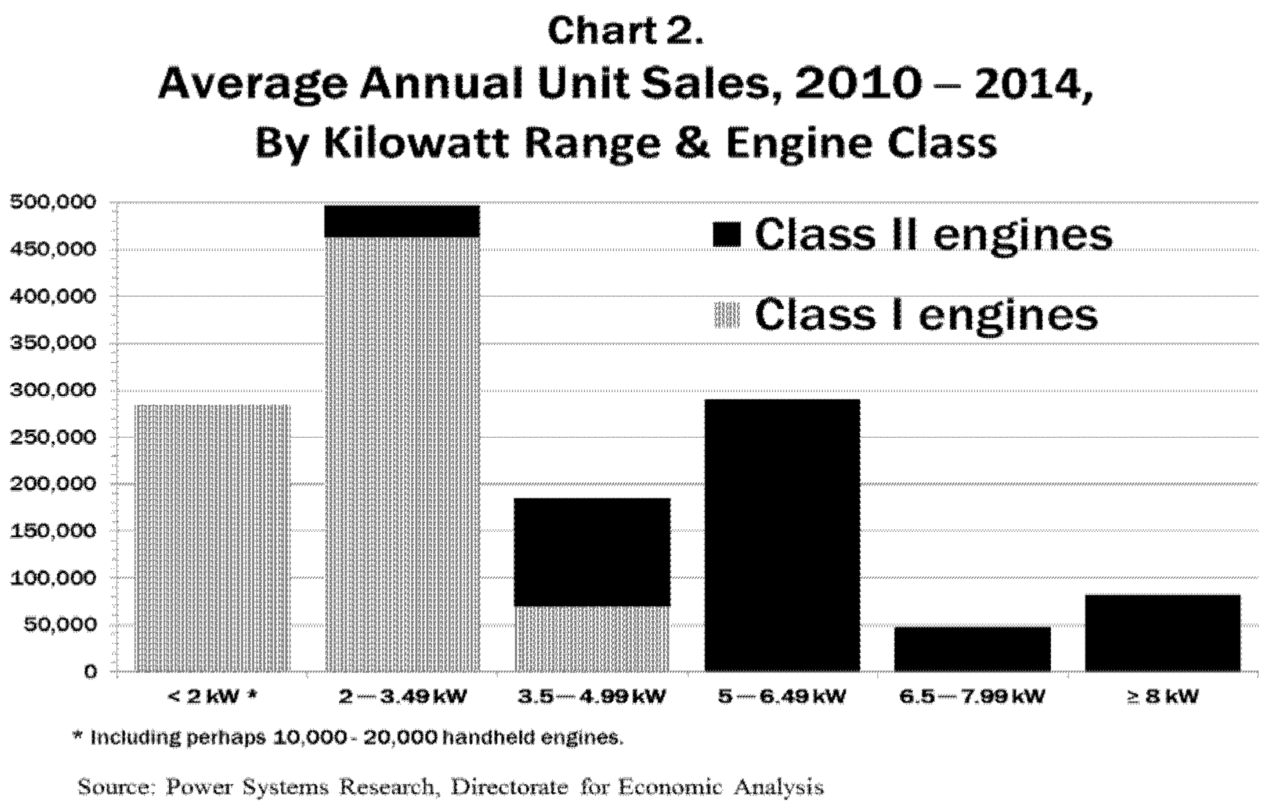
Small spark-ignition engines used in the manufacture of portable generators are classified (by EPA and for the CPSC proposed rule) according to their total cylinder displacement in cubic centimeters (cc). Data on this engine characteristic were obtained from PSR and individual firms for recent shipments of portable generators, which enabled CPSC to estimate engine classes for the kilowatt ranges discussed above. Data on shipments of portable generators for 2010 through 2014 show that portable generators with Class I engines (those with a total cylinder displacement of <225 cc) comprised about 59 percent of units shipped, and those with Class II engines (those with total displacement ≥225 cc) comprised about 41 percent. We estimate that total annual shipments of portable generators over 2010 to 2014 averaged almost 1.4 million units; about 816,000 of these generators had Class I engines and about 568,000 had Class II engines.

Although sometimes used in non-handheld equipment (such as portable generators), engines are classified as handheld by EPA if they have total displacement of less than or equal to 80 cc. Based on information provided by PSR and individual firms, we estimate that generators with handheld engines account for an average of about 10,000 to 20,000 units sold annually; about 1 percent of the overall consumer market for portable generators; and perhaps 2 percent of the units with smaller (<225 cc) engines.

Chart 2 shows the relationship between rated kilowatt power of portable generators and their engine classes for 2010 through 2014. As can be seen, generators with rated power of under 2 kW were made with Class I engines; and virtually all of those with rated power of 5 kW or greater were made with Class II engines. For units with 2 to 3.49 kW (which was the largest single kW category, accounting for 36 percent of units in 2010 to 2014), the great majority (93%) were made

[87] It is possible that some of the demand for generators with greater power in recent years has been increasingly met by sales and installation of stationary stand-by generators.

with Class I engines, while a majority (63%) of units with rated power in the range of 3.5 to 5 kW were made with Class II engines.



Engine Cylinders

Engines used in the manufacture of portable generators intended for consumer use have either one or two cylinders for combustion of fuel. Based on information on engine characteristics gathered and reported by PSR, virtually all of the portable generators with sustained power ratings below 6.5 kW that were sold from 2010 to 2014 were powered with one-cylinder engines. These power categories comprised about 91 percent of all units purchased by consumers during that period, as shown in Table 1. PSR data reveal that one-cylinder engines powered about 91 percent of the generators with 6.5 to 7.99 kW and about 58 percent of units with power ratings from 8 to 9.99 kW. It is in more powerful generators, with sustained power ratings of 10 kW and greater, that two-cylinder engines are more common, accounting for about 93 percent of units sold from 2010 to 2014. Overall, the data indicate that one-cylinder engines were used in the manufacture of at least 95 percent of total unit sales of portable generators to consumers, and in about 89 percent of the Class II engines used to produce portable generators.

Fuel Distribution Systems

The Commission believes that compliance with the CO emission requirements of the proposed rule likely would lead OEM manufacturers of portable generators to select engines that have fuel distribution systems that are more capable of controlling air-to-fuel ratios than traditional carbureted systems.[88] Specifically, manufacturers are expected to switch to use of electronic fuel injection (EFI) instead of conventional carburetors to control the delivery of gasoline to the pistons of generator engines. The Commission is aware of at least five portable generator manufacturers that have either developed models with EFI for evaluation or actually marketed such models within the last 2 years; and some of these models have been evaluated by the Commission at the National Product Test and Evaluation Center.[89] However, virtually all generators currently in consumer use have carbureted fuel distribution systems.

[88] Tab I of staff's briefing package.

[89] See Tab J of staff's briefing package.

Engine Cycles

Spark-ignition engines used in portable generators have either two or four piston strokes per combustion cycle. Two-stroke engines have simpler designs with fewer moving parts, making them easier to maintain and lighter in weight at a given displacement than four-stroke engines. They also reportedly can produce up to 40 percent more power than four-stroke engines with the same displacement (MECA, 2009). These characteristics, and the ability to operate in many directions without flooding, make two-stroke engines attractive for use in handheld equipment, such as chainsaws, trimmers and leaf-blowers. Portable generators and other larger non-handheld equipment, such as lawn and garden equipment and pressure-washers, typically have 4-stroke engines. Although all of the portable generators reported in PSR's database of recent shipments had 4-stroke engines, the Commission found portable units with small (<80 cc) 2-stroke engines advertised for sale on internet Web sites. These units likely comprise an extremely small share of the market for portable generators.

Retail Prices

With the wide range of engine power and other features available on portable generators shipped in recent years, these products also have been offered to consumers at a wide range of retail prices. The most recent survey data on retail prices was provided to the Commission by Synovate and covered the years 2004 through 2006. Consumer survey data developed by Synovate found that the average retail price paid by consumers for portable generators intended primarily for backup power in the event of electric power outages (the primary stated purpose for the purchase by about 75% of consumers) was about $1,040 in 2006.

More recent pricing information was gained through an informal survey of advertised prices for portable generators by CPSC staff in October 2015 (which included units available in stores and via the Internet). This survey found that that retail prices generally vary by kW rating of the units, engine class and number of cylinders. For rated generator power, average prices were $393 for units under 2 kW; $606 for 2 to 3.49 kW generators; $640 for 3.5 to 4.99 kW units; $936 for those with 5 to 6.49 kW ratings; $1,002 for units with 6.5 to 7.99 kW ratings; and $1,745 for units with kW ratings of 8 or more. Generator characteristics other than power ratings also affect price. For example, ''inverter generators'' have electronic and magnetic components that convert the AC power to DC power, which is then ''inverted'' back to clean AC power that maintains a single phase, pure sine wave at the required voltage and frequency suitable for powering sensitive equipment, such as computers. These additional components add to the manufacturing cost, resulting in significantly higher retail prices than units with similar power outputs. For example, our limited retail price survey found that the average retail prices of generators with power ratings of under 2 kW were $242 for units not identified as inverters and $710 for those identified as inverters.

Regarding retail price information by engine class and number of cylinders, staff's informal survey found that generators with handheld engines ranged in price from $133 to $799, with an average price of about $324. Generators with non-handheld Class I engines had a wide price range, from $190 to more than $2,000, with an average price of $534. Generators with one-cylinder Class II engines ranged in price from $329 to $3,999, with an average price of $1,009. Generators with two-cylinder Class II engines ranged in price from $1,600 to $4,999, and the average price of these units was $2,550.

Table 7 shows selected characteristics (displacement, power rating, price and weight) for generators found in an informal retail market survey of generators, by engine class and type.

Table 7.
Sample Characteristics of Portable Generators Recently Marketed, by Engine Class/Type

Product Characteristic		Handheld	Class I	One-Cylinder, Class II	Two-Cylinder, Class II
	Sample size (n)[1]	(43)	(261)	(412)	(35)
Engine Displacement (cc)	Range	31 to 80	87 to 224	250 to 459	530 to 992
	Average	67.7	185.6	389.2	703.9
	Median	79	206	389	680
Power Ratings (watts)	Range	450 to 1,700	1000 to 4,375	3,500 to 9,200	9,000 to 17,500
	Average	1,094	2,968	6,230	11,771
	Median	1,050	3,250	6,200	10,500
Retail Prices	Range	$133 to $799	$190 to $2,324	$329 to $3,999	$1,600 to $4,999
	Average	$324 (24)	$534 (151)	$1,009 (226)	$2,550 (20)
	Median	$225 (24)	$439 (151)	$899 (226)	$2,439 (20)
Weight (lbs.)	Range	19 to 62	45.6 to 140	115 to 320	278 to 471
	Average	44.6 (22)	101.8 (124)	204.3 (174)	333.8 (14)
	Median	46.0 (22)	105.5 (124)	204.0 (174)	330.0 (14)

Source: Directorate for Economic Analysis, CPSC, informal market survey of portable generators offered for sale by selected major retailers in 2015 and 2016 (price information limited to 2015).

[1] Sample size pertains to engine displacement and power rating. Smaller sample sizes for retail prices and weights are reported with the averages and medians for those product characteristics.

D. Portable Generators in Use

In this section, we estimate the population of portable generators in use, averaged over the period 2004 to 2012, analyzed by the Directorate for Epidemiology, Division of Hazard Analysis.[90] Estimates of the number of generators in use represent a measure of

[90] Tab A of staff's briefing package.

risk exposure and is the necessary first step in calculating product-related risks (*e.g.,* generator-related deaths and injuries divided by the population of generators in use), determining the per-unit societal costs of deaths and injuries that would be addressed by the proposed standard, and finally, estimating the possible benefits of the proposed rule.

We estimated the population of portable generators in use with the CPSC's Product Population Model (PPM), a computer model that projects the number of products in use, given estimates of annual product sales and their expected product life.[91] The expected useful life of generators, in years, is largely a function of engine size, loads placed upon the unit and hours of use. Portable generators primarily purchased for household backup power that are mainly used during occasional or rare power outages could have useful lives much longer than 10 years if they are maintained properly. An evaluation of data on historical sales in relation to surveys of product ownership suggests an expected useful product life of about 11 years. An assumption of a considerably shorter expected useful life using data on historical annual unit shipments would yield estimated numbers of units in use and saturation rates that are well below those indicated by Synovate survey data from 2005, as well as industry estimates of ownership in recent years.[92]

Table 8 presents the product population estimates for the years 2004 through 2012; estimated totals have increased from about 9.9 million in 2004, to about 12.5 million in 2012. The average for the years 2004 to 2012 was about 11 million units in use. Table 8 also presents estimates of the numbers of portable generators in use by ranges of kW ratings. These estimates were based on (1) portable generator shipment and purchase data provided by PSR and Synovate for the years 2004 through 2013, augmented by estimates of annual sales developed for some individual manufacturers; and (2) estimates of aggregate annual sales for prior years, in combination with Synovate estimates of market shares for the various power categories for previous years. The PPM was then used to estimate the product population for each power category, assuming an 11-year average product life. According to the population estimates, the largest power category was generators 5 to 6.49 kW, accounting for an average of 3.6 million units in use, or about 33 percent of the total, followed by generators 3.5 to 4.99 kW (averaging about 2 million units and 18.2% of the total).

Table 8. Estimated Units of Portable Generators in Use, by Generator kW Ratings, 2004 - 2012

Year	< 2 kW	%	2—3.49 kW	%	3.5—4.99 kW	%	5—6.49 kW	%	6.5—7.99 kW	%	8 kW +	%	Total
2004	1,164,937	11.8%	1,514,418	15.3%	2,003,691	20.2%	3,307,573	33.4%	1,125,797	11.4%	785,440	7.9%	9,901,855
2005	1,169,828	11.2%	1,507,610	14.5%	2,052,923	19.7%	3,620,229	34.8%	1,218,983	11.7%	843,880	8.1%	10,413,454
2006	1,138,111	10.9%	1,494,780	14.3%	2,026,543	19.4%	3,684,521	35.3%	1,234,027	11.8%	865,844	8.3%	10,443,826
2007	1,138,122	10.8%	1,507,516	14.3%	2,019,291	19.2%	3,721,225	35.3%	1,246,975	11.8%	908,152	8.6%	10,541,281
2008	1,225,495	11.2%	1,657,508	15.2%	2,029,573	18.6%	3,804,931	34.8%	1,246,355	11.4%	965,614	8.8%	10,929,475
2009	1,382,555	12.3%	1,945,110	17.3%	2,006,405	17.8%	3,755,195	33.4%	1,189,234	10.6%	966,810	8.6%	11,245,308
2010	1,565,789	13.5%	2,278,780	19.6%	2,001,427	17.2%	3,686,827	31.7%	1,133,894	9.8%	962,137	8.3%	11,628,854
2011	1,724,038	14.4%	2,579,743	21.6%	1,988,252	16.6%	3,641,605	30.4%	1,071,810	9.0%	961,550	8.0%	11,966,999
2012	1,906,637	15.3%	2,943,773	23.6%	2,001,557	16.1%	3,626,361	29.1%	1,012,496	8.1%	968,748	7.8%	12,459,571
9-Year Average	1,379,501	12.5%	1,936,582	17.5%	2,014,407	18.2%	3,649,830	33.0%	1,164,397	10.5%	914,242	8.3%	11,058,958

Source: CPSC Directorate for Economic Analysis, based on Product Population Model evaluation of estimated historical sales.

Note that the estimates provided in Table 8 assume uniform expected product lives across engine sizes and power ratings; that is, the generators with smaller engine sizes are assumed to last as long as the larger engine sizes. Larger engines usually are rated for more hours of operation than smaller engines. Assuming the hour ratings reflect the relative differences in total hours of actual use, our estimates imply fewer hours of use per year for smaller generators versus larger units over their useful lives. This issue is addressed in the sensitivity analysis, and information regarding product lives of units and average annual hours of operation

[91] Lahr, M.L. & Gordon, B.B. (1980). Product life model feasibility and development study. Contract CPSC–C–79–009, Task 6, Subtasks 6.01–6.06). Columbus, OH: Battelle Columbus Laboratories.

[92] For example, portable and stationary generator manufacturer, Generac, reportedly estimated that about 12 percent of households had portable generators in 2013, up from 10 percent in 2010 (Hill, 2013).

would be welcome from industry and the public.

The proposed rule specifies different requirements for CO emission rates depending on generator engine class and other objective characteristics, rather than engine or generator power ratings. The Directorate for Economic Analysis has estimated historical sales of generators by engine class from estimated sales by kW ratings using data from PSR reporting both generator power and engine displacement. Table 9 presents estimated units in use for 2004 to 2012, by engine class. Based on our analysis, the proportion of generators with smaller engines (handheld and Class I) has increased over the 9-year period. This is consistent with estimates of the increasing share of generators in use with power ratings of under 3.5 kW, shown in Table 8, which follows from the information presented regarding the apparent shift in the U.S. market towards smaller, less powerful units.

Table 9.

Estimated Units of Portable Generators in Use, by Generator Engine Class, 2004 – 2012

Year	Handheld Engines		Class I Engines		Class II Engines				All Units
					1-Cylinder		2-Cylinders		
	Units	Percent	Units	Percent	Units	Percent	Units	Percent	
2004	67,418	0.7%	3,317,468	33.5%	5,826,761	58.8%	690,209	7.0%	9,901,855
2005	67,701	0.7%	3,335,886	32.0%	6,266,611	60.2%	743,256	7.1%	10,413,454
2006	65,866	0.6%	3,283,911	31.4%	6,333,338	60.6%	760,711	7.3%	10,443,826
2007	65,866	0.6%	3,293,317	31.2%	6,390,317	60.6%	791,781	7.5%	10,541,281
2008	70,923	0.6%	3,521,657	32.2%	6,504,141	59.5%	832,755	7.6%	10,929,475
2009	80,012	0.7%	3,932,257	35.0%	6,405,261	57.0%	827,778	7.4%	11,245,308
2010	90,616	0.8%	4,418,072	38.0%	6,301,520	54.2%	818,646	7.0%	11,628,854
2011	99,775	0.8%	4,846,279	40.5%	6,208,911	51.9%	812,035	6.8%	11,966,999
2012	110,342	0.9%	5,367,384	43.1%	6,170,376	49.5%	811,468	6.5%	12,459,571
9-Year Average	79,835	0.7%	3,924,026	35.5%	6,267,471	56.7%	787,626	7.1%	11,058,958

Source: CPSC Directorate for Economic Analysis, based on Product Population Model evaluation of estimated historical sales.

E. Benefit—Cost Analysis

This section of the analysis consists of a comparison of the benefits and costs of the proposed rule. The analysis is conducted from a societal perspective, considering all of the significant costs and health outcomes. Benefits and costs are calculated on a per-product-in-use basis. The benefits are based on the reduced risk of fatal and nonfatal injury due to CO poisoning involving portable generators. The costs are defined as the added costs of making the portable generators comply with the proposed rule.

Our primary outcome measure is the expected net benefits (*i.e.,* benefits minus costs) of the proposed rule. As noted above, our primary analysis calculates the benefits and costs of the rule on a per-product-in-use basis. However, aggregated estimates of the benefits and cost on an annual basis can be readily calculated, given projections of annual generator sales.

1. Societal Costs of Portable Generator Deaths and Injuries

As discussed in Section III, the Directorate for Epidemiology, Division of Hazard Analysis (EPHA) reports that there were 659 deaths involving portable generators from 2004 to 2012, an average of about 73 annually.[93] The average annual societal costs of these CO deaths are estimated to be about $637 million in 2014 dollars, based on a value of a statistical life (VSL) of $8.7 million.[94]

[93] Tab A of staff's briefing package.

[94] The estimated value of a statistical life (VSL) of $8.7 million (in 2014 dollars) is a revision of the VSL estimated by the U.S. Environmental Protection Agency and is generally consistent with other estimates based on willingness-to-pay. Kneiser et al. (2012), suggested that a reasonable range of values for VSL was between $4 million and $10 million (in 2001 dollars), or about $5.3 million to $13.3 million in 2014 dollars (BLS 2015).

EPHA also provided an estimate of CO-related injuries involving portable generators, based on estimates from the National Electronic Injury Surveillance System (NEISS) during the years 2004 through 2012.[95] According to EP, there was a minimum of 8,703 nonfatal CO poisonings involving portable generators that were treated in hospital emergency departments from 2004 through 2012, or a minimum of about 967 annually.[96] This NEISS estimate is considered a minimum because the estimate only included injuries that were explicitly attributed to CO poisoning injuries in the NEISS narrative.

The NEISS injury estimates are limited to individuals initially treated in hospital emergency departments. However, the CPSC's Injury Cost Model (ICM) uses empirical relationships between the characteristics of injuries and victims in cases initially treated in hospital emergency departments and those initially treated in other medical settings (*e.g.,* physicians' offices, ambulatory care centers, emergency medical clinics), based primarily on data from the Medical Expenditure Panel Survey,[97] to estimate the number of medically attended injuries that were treated outside of hospital emergency departments. The ICM also analyzes data from the Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project [98] to project the number of direct hospital admissions bypassing the hospital emergency departments. According to the ICM estimates, there were an additional 16,660 medically attended injuries during 2004 to 2012, or about 1,851 annually. Consequently, based on NEISS and ICM estimates, there was a minimum of about 2,818 medically attended injuries (967 ED + 1,851 non-ED) treated annually during the 9-year period.

The ICM is fully integrated with NEISS and provides estimates of the societal costs of injuries reported through NEISS, as well as the costs associated with the estimated medically attended injuries treated outside of hospital emergency departments. The major aggregated societal cost components provided by the ICM include medical costs, work losses, and the intangible costs associated with lost quality of life or pain and suffering.

Medical costs include three categories of expenditures: (1) Medical and hospital costs associated with treating the injury victim during the initial recovery period and in the long run; the costs associated with corrective surgery; the treatment of chronic injuries, and rehabilitation services; (2) ancillary costs, such as costs for prescriptions, medical equipment, and ambulance transport; and (3) costs of health insurance claims processing. Cost estimates for these expenditure categories were derived from a number of national and state databases, including the Medical Expenditure Panel Survey, the Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project, the Nationwide Emergency Department Sample,[99] the National Nursing Home Survey,[100] MarketScan® [101] claims data, and a variety of other federal, state, and private data.

Work loss estimates are based on information from the Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project, the Nationwide Emergency Department Sample, Detailed Claims Information (a workers' compensation database), the National Health Interview Survey, the U.S. Bureau of Labor Statistics and other sources. These estimates include: (1) Forgone earnings of the victim, including lost wage work and household work; (2) forgone earnings of parents and visitors, including lost wage work and household work; (3) imputed long-term work losses of the victim that would be associated with permanent impairment; and (4) employer productivity losses, such as the costs incurred when employers spend time juggling schedules or training replacement workers.

Intangible, or noneconomic, costs of injury reflect the physical and emotional trauma of injury, as well as the mental anguish of victims and caregivers. Intangible costs are difficult to quantify because they do not represent products or resources traded in the marketplace. Nevertheless, they typically represent the largest component of injury cost and need to be accounted for in any benefit-cost analysis involving health outcomes.[102] The ICM develops a monetary estimate of these intangible costs from jury awards for pain and suffering. Although these awards can vary widely on a case-by-case basis, studies have shown them to be systematically related to a number of factors, including economic losses, the type and severity of injury, and the age of the victim (Viscusi, 1988; Rodgers, 1993).[103] Estimates for the ICM were derived from regression analysis of jury awards compiled by Jury Verdicts Research, Inc., for nonfatal product liability cases involving consumer products.

According to the ICM, the estimated injury costs of the approximately 2,817 medically attended portable generator CO injuries annually amounted to about $184 million (in 2014 dollars), an estimated average of $65,400 per injury. Medical costs and work losses accounted for about 53 percent of the total, while the non-economic losses associated with pain and suffering accounted for about 47 percent. The societal costs of both fatal and nonfatal CO poisoning injuries involving portable generators amounted to about $821 million ($637 million for fatal

[95] Stephen Hanway, Division Director, Division of Hazard Analysis, Directorate for Epidemiology, CPSC. Memorandum to Gregory B. Rodgers, AED, Directorate for Economic Analysis, CPSC: ''Injuries associated with generators seen in emergency departments with narratives indicative of CO poisoning 2004–2012 for injury cost modeling,'' October 6, 2015.

[96] Tab H of staff's briefing package.

[97] The Medical Expenditure Panel Survey (MEPS) is a nationally representative survey of the civilian non-institutionalized population that quantifies individuals' use of health services and corresponding medical expenditures. The MEPS is administered by the Agency for Healthcare Research and Quality (AHRQ). The MEPS has been collected continuously since 1999 and is the principal data set used to monitor medical spending in the U.S.

[98] The National (Nationwide) Inpatient Sample (NIS) is part of a family of databases and software tools developed for the Healthcare Cost and Utilization Project (HCUP). The NIS is the largest publicly available all-payer inpatient health care database in the United States, yielding national estimates of hospital inpatient stays. HCUP is a family of health care databases and related software tools and products developed through a Federal-State-Industry partnership and sponsored by the Agency for Healthcare Research and Quality (U.S. Department of Health & Human Services).

[99] The Nationwide Emergency Department Sample (NEDS) is part of a family of databases and software tools developed for the Healthcare Cost and Utilization Project (HCUP). The NEDS is the largest all-payer emergency department (ED) database in the United States, yielding national estimates of hospital-based ED visits.

[100] The National Nursing Home Survey (NNHS) is a series of nationally representative sample surveys of United States nursing homes, their services, their staff, and their residents. The NNHS was first conducted in 1973–1974 and repeated in 1977, 1985, 1995, 1997, 1999, and most recently in 2004.

[101] The MarketScan® Commercial Claims and Encounters (MarketScan) Database from Truven Health Analytics contains de-identified, person-specific health data of reimbursed healthcare claims for employees, retirees, and their dependents of more than 250 medium and large employers and health plans.

[102] Rice, D., MacKenzie, E. & Associates (1989). Cost of injury in the United States: A report to Congress. San Francisco, CA: Institute for Health & Aging, University of California and Injury Prevention Center, The Johns Hopkins University.

[103] Viscusi, W.K. (1988). The determinants of the disposition of product liability cases: Systematic compensation or capricious awards? *International Review of Law and Economics,* 8, 203–220; Rodgers, G. (1993). Estimating jury compensation for pain and suffering in product liability cases involving nonfatal personal injury. *Journal of Forensic Economics* 6€, 251–262.

injuries + $184 million for nonfatal injuries) annually.

The average annual societal cost estimates for generators in use in 2004 through 2012, by engine class, are presented in more detail in Table 10. Row 1 provides the annual estimates of fatal CO poisoning injuries by engine class, and the estimated percent of all deaths involving each category. Note that information on engine class for generators involved in the deaths was available on only about 48 percent of the cases. The cases in which the engine classes were not known were distributed proportionally to the cases in which the classes were known.

Row 2 shows estimated annual nonfatal injuries by engine class; the nonfatal CO injuries were distributed proportionally to the deaths because very little information is available on the displacement of engines of generators involved in these injuries. Row 3 provides estimates of the aggregate annual societal costs of the deaths and injuries. Societal costs were based on a VSL of $8.7 million per death, and the nonfatal injury costs are from the ICM modeling. Row 4 provides the annual estimates of portable generators in use by engine class, as well as the estimated percent of all units in use for each category. Row 5 provides annual per-unit societal costs of deaths and injuries, which is based on the Row 3 estimates divided by the estimated numbers of portable generators in use (shown in Row 4).

Table 10.
Estimated Units of Portable Generators in Use and Expected Societal Costs of CO Poisoning, by Generator Engine Class, 2004 – 2012

	Handheld Engines	Class I Engines	Class II Engines		All Units
			1-Cylinder	2-Cylinder	
Estimated Deaths / Year (Percent)	0.5 0.7%	25.6 35.0%	46.2 63.0%	0.9 1.2%	73.2 100.0%
Estimated Nonfatal Injuries / Year	21	986	1,776	34	2,818
Aggregate Annual Societal Costs of Deaths and Injuries (million $)	$6.0	$287.6	$517.8	$10.0	$821.3
Estimated Number of Units in Use (Average, 2004 – 2012) (Percent)	79,835 0.7%	3,924,026 35.5%	6,267,471 56.7%	787,626 7.1%	11,058,958 100.0%
Annual Societal Costs of CO Poisonings / Unit	$74.90	$73.29	$82.62	$12.66	$74.27
Total Present Value of Expected Societal Costs of Deaths and Injuries / Unit	$687	$672	$758	$116	$682

Finally, Row 6 provides per-unit estimates of the present value of the expected societal costs (at a 3% discount rate) over the expected product life of a generator. This figure is useful in benefit-cost analysis because it represents the maximum per-unit benefits that might be derived from a product safety standard, if the standard prevented all deaths and injuries. The present value of expected societal costs is $687 per unit for portable generators with handheld engines (which are estimated to have accounted for less than 1% of units in use during the period 2004 through 2012); $672 per unit for generators with Class I engines (35.5% of units in use); $758 per unit for generators with one-cylinder Class II engines (56.7% of units in use); and $116 per unit for generators with two-cylinder Class II engines (7.1% of units in use). The societal costs associated with the two-cylinder Class II generators are substantially lower than for the other generator categories because of the small relative risk for the two-cylinder models. Because the two-cylinder models accounted for about 7.1 percent of generators in use, but only about 1.2 percent of the deaths, the risk of death with two-cylinder generators was only about 16 percent of the risk associated with generators with one-cylinder engines (*i.e.,* handheld, Class I, and one-cylinder Class II generators). The average expected present value of societal costs of CO poisoning deaths and injuries for all portable generators is $682 per unit. These calculations also represent baseline estimates of the societal costs associated with portable generators, by engine class and other characteristics: Estimates of what per-unit societal costs would be in the absence of regulatory action. Benefits of the proposed rule can, therefore, be estimated as the expected reduction in the baseline societal costs.

2. Estimated Benefits of the Proposed Rule

As described in Section IX, the requirements of the proposed performance standard require portable generators powered by handheld engines and Class I engines to emit CO at a weighted rate that is no more than 75 grams per hour (g/hr); generators powered by one-cylinder Class II engines to emit CO at a weighted rate that is no more than 150 g/hr; and generators powered by two-cylinder Class II engines to emit CO at a weighted rate that is no more than 300 g/hr. As noted in CPSC staff's analysis that provides the rationale for the performance requirements, considering expected manufacturing variability of ±50 percent, based on limited testing of pairs of generators, as described in the staff's briefing package, these emission requirements reflect a factor of 1.5 over the expected technically feasible emission rates for each engine classification: 50 g/h for those with handheld and Class I engines; 100 g/h for those with one-cylinder Class II engines; and 200 g/h for those with two-cylinder Class II engines.[104] Comments and additional data on expected manufacturing variability would be welcome, given the limited data available to staff to evaluate variability.

To estimate the expected reduction in societal costs, and hence, the benefits from the proposed rule for portable generators, an interdisciplinary analysis by CPSC staff provided estimates of generator-related consumer CO poisoning deaths reported in the agency's databases that could have been avoided as a result of reduced CO emission rates from generators. An important part of the analysis was indoor air quality modeling by NIST under an interagency agreement to estimate the transport of CO emitted from generators and predicted health effects for scenarios and house characteristics found in CPSC's incident data. CPSC staff then compared the health effects resulting from emission rates from current generators to a range of lower CO emission rates to estimate deaths that could have been avoided for each emission rate.[105]

The NIST modeling and CPSC staff analysis considered scenarios associated with 503 CO poisoning deaths over 2004 to 2012, or about 76 percent of the 659 CO poisoning deaths in CPSC records over the 9-year period. These deaths occurred at various fixed-structure residential settings, including traditional houses, mobile homes, townhomes, and structures attached to a home, in addition to residential sites where generators were operated in separate structures, such as sheds cabins used for temporary (non-residential) shelter and detached garages. For the purposes of this analysis, deaths and injuries occurring in these settings are considered to be those that would be which would be addressable by the proposed rule. However, we note that an unquantified number of the 156 deaths not modeled by NIST might be addressed and prevented by the proposed rule.[106]

Chart 3 presents the results of CPSC staff analyses of estimated reductions in CO poisoning fatalities that would result from lower-weighted emission rates for modeled scenarios under various weighted CO emission rates. At each reduced emission rate, the estimated percentage reduction in fatalities is greater for generators powered with larger engines because of their higher average estimated base rate for CO emissions (4700 g/h for one-cylinder and 9100 g/h for two-cylinder Class II engines vs 1800 g/h for Class I non-handheld engines and 900 g/h for handheld engines).[107] In CPSC engineering staff's judgment, the technically feasible weighted CO emission rates are 50 g/h for generators powered by handheld and Class I engines, 100 g/h for generators powered by one-cylinder Class II engines, and 200 g/h for generators with two-cylinder Class II engines.[108]

Emission rates from generators meeting the proposed performance requirements are expected to be higher while operating indoors (at reduced oxygen levels of approximately 17%) than the feasible rates under conditions of approximately 20.9% oxygen: Perhaps 150 g/h for generators with handheld engines and Class I engines, 300 g/h for generators with one-cylinder Class II engines and 600 g/h for generators with two-cylinder Class II engines (three times the technically feasible rate for each generator category).[109] Based on staff's analysis of 503 deaths (76 percent of all deaths) modeled by NIST (and generally deemed to be addressable by the proposed standard), these emission rates are expected to result in about a 47 percent reduction in (addressable) fatalities involving generators with handheld engines; about a 49 percent reduction in fatalities involving generators with Class I engines; a 37 percent reduction for those with one-cylinder Class II engines: And a reduction of about 17 percent for generators with two-cylinder Class II engines. The average expected reduction in CO poisoning fatalities across generators of all engine types is about 44 percent of the addressable deaths and injuries, or about 33 percent of all generator-related deaths and injuries (44% × 76%).

[104] Tab I of staff's briefing package.

[105] See Tab K of staff's briefing package.

[106] *IBID.*

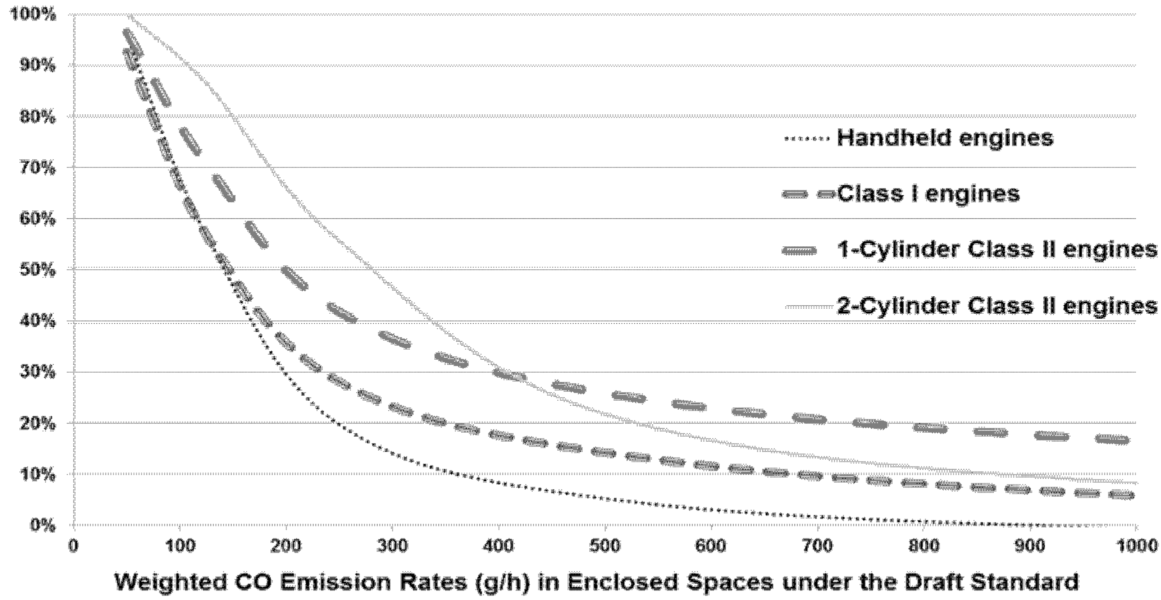
[107] These rates assume a factor of 3 in the increase in CO emission rate of a generator operating in an enclosed space compared to operation outdoors in normal oxygen. This factor of 3 is based on testing of carbureted generators conducted by NIST (Emmerich, Polidoro & Dols, *op. cit.*) and CPSC staff (Brookman, 2016, TAB J of the NPR Briefing Package).

[108] See Tab I of staff's briefing package.

[109] Based on CPSC's testing of three generators with fuel-injected engines having different degrees of closed-loop operation (see TAB J of staff's briefing package), CPSC believes the factor of increase when the oxygen is 17 percent may be less than 3 for some generators that use closed-loop EFI. Furthermore, test results from NIST (Buyer, 2012) indicate the prototype EFI generator depleted the oxygen significantly less than the carbureted generator, when tested in each of four matched-pair identical test scenarios. Nevertheless, CPSC assumes in the benefits analysis a conservative factor of 3 for the increase in CO emissions for low-emission generators when operating at reduce oxygen levels of 17 percent. Therefore, the factor of 3 likely overstates the weighted CO emission rates for EFI generators when operated indoors, and understates the reduction in deaths and injuries resulting from the draft standard.

Chart 3.

Estimated Reduction (%) in CO Poisoning Fatalities for Scenarios Modeled by NIST, Depending on CO g/h Resulting from the Standard*



* Estimated base CO emission rates at reduced O_2 average about 900 g/h for generators with handheld engines; 1800 g/h for generators with non-handheld Class I engines; 4700 g/h for generators with one-cylinder Class II engines and 9100 g/h for generators with two-cylinder Class II engines.

Table 11 presents estimated reductions in societal costs, and hence, benefits of the reduced CO emissions predicted to result from the proposed standard. The per-unit societal costs per generator, from Table 10, are included at row 1. However, as noted above, not all of these costs would be addressed by the proposed standard or were not included among the major residential scenarios modeled by NIST.[110] The present value of expected societal costs of CO poisoning that would be addressed by an emission standard are shown in row 2 and average about $514 for generators with Class I engines and about $586 for generators with one-cylinder Class II engines—engine categories that combine for an estimated 92 percent of portable generators in use. Generators with handheld engines, estimated to account for less than 1 percent of units in use, are estimated to average $525 in societal costs. Generators with two-cylinder Class II engines are estimated to average $26 in societal costs of CO poisoning over their useful lives. These larger generators are estimated to account for about 7 percent of all units in use.

Row 3 shows the staff's estimates of weighted CO emissions from complying generators of the different engine categories that would result from operation in conditions of reduced oxygen. Row 4 shows the estimated reduction in addressable societal costs resulting from the weighted emission rates, based on CPSC staff's estimate of the reduction in CO poisoning deaths.[111] Our estimate of reduction in societal costs of CO poisoning deaths and injuries assumes that projected injury costs from annual production of generators will fall in proportion to estimated death reduction, with a minor adjustment to account for the possibility that deaths avoided by reduced CO emissions would still occur as injuries.[112] With projected reductions in deaths and injuries under the proposed standard, the present value of benefits (shown in row 5 of Table 10) is estimated to average about $243 for generators with handheld engines; $254 per unit for generators with Class I engines; $214 per unit for generators with one-cylinder Class II engines; and $4 for generators with two-cylinder Class II engines. Average projected present value of benefits for all portable generators is about $227 per unit.

Multiplying the present value of expected benefits per unit by estimated annual unit sales (in row 6) yields the estimated aggregate present value of benefits from annual sales of portable generators that would comply with the proposed standard. The estimated present value of benefits of reduced CO poisoning from complying portable generators sold in a year totals about $315 million. Nearly 99 percent of the total benefits are attributable to expected sales of generators with Class I engines and one-cylinder Class II engines. These two types of engines are expected to comprise about 94 percent of annual unit sales under the proposed standard.

[110] About 76 percent of all CO poisoning deaths from 2004 to 2012 involved scenarios that were modeled by NIST. Among the scenarios that were not modeled are those involving CO poisoning deaths in apartments, vehicles and trailers (non-mobile homes), and other structures, such as a church, a sea-land container, and tents.

[111] Tab K of the staff's briefing package.

[112] We have assumed that avoided deaths under the proposed rule would still occur as nonfatal CO injuries of average severity and cost.

Table 11.
Estimated Present Value of Societal Costs from CO Poisoning Involving Portable Generators and Expected Benefits Under the Proposed Standard, by Generator Engine Class & Characteristics

	Handheld Engines	Class I Engines	Class II Engines		All Units
			1-Cylinder	2-Cylinders	
Total Present Value of Expected Societal Costs of Deaths and Injuries / Unit	$687	$672	$758	$116	$682
Estimated Present Value of Societal Costs per Unit Addressed by The Draft Standard	$525	$514	$586	$26	$520
Estimated Weighted CO Emission Rate Under the Draft Standard in Conditions of Reduced Oxygen	150	150	300	600	
Estimated Reduction in Addressable Societal Costs of CO Poisoning*	47%	50%	37%	17%	44%
Expected Benefits per Unit: Present Value of Expected Reduction in Societal Costs	$243	$254	$214	$4	$227
Estimated Annual Unit Sales (Percent)	15,000 1.1%	800,502 57.8%	503,576 36.4%	64,818 4.7%	1,383,896 100.0%
Present Value of Expected Reduction in Societal Costs from Units Sold Annually (Millions $)	$3.6	$203.1	$107.5	$0.3	$314.5

* Based on estimated reduction in CO poisoning deaths by CPSC staff (Hnatov, Inkster & Buyer, 2016)

Projections of benefits of the proposed rule should account for recent changes, and reasonably expected changes, in the market that will affect societal costs and the costs of compliance by manufacturers. One consideration that would be expected to reduce the addressable societal costs of the rule from those estimated for the period of 2004 to 2012 is the relatively recent introduction of units with EFI. Increased use of EFI would also reduce the costs of compliance with a standard based on reduced CO emissions. However, portable generators with EFI have not yet gained a significant share of the consumer market for portable generators, and we have little basis for incorporating projected sales of EFI units into the analysis. Regarding the introduction of EFI on expected hazard costs, most of the EFI-equipped portable generators have reportedly not targeted reductions in CO emissions, specifically. Therefore, a relatively small share of the generator market would not be expected to contribute to substantial reduction in the overall hazard. However, costs of compliance with a mandatory standard would be greatly reduced for units with EFI systems.

In addition to reducing societal costs related to CO poisoning deaths and injuries, product modifications to achieve greatly reduced CO emissions could also result in improved fuel efficiency and other benefits, including easier starting, altitude compensation, fuel adaptability, improved power, better reliability and longer useful product life.

3. Estimated Costs of Compliance With the Proposed Rule

a. Costs of Compliance per Unit

Based on the judgment of CPSC engineering sciences staff, the most likely technical means of compliance with the requirements of the proposed rule would be the use of closed-loop electronic fuel-injection systems to achieve and maintain the needed air-to-fuel ratios under different loads and ambient conditions.[113] Another element expected to be part of the industry's technical response to the proposed standard is the addition of 3-way catalysts in the muffler systems of portable generator engines. Besides achieving further reductions in CO emissions, these catalysts would likely serve to reduce HC and NO_X emissions for continued compliance with EPA emission standards for small spark-ignition engines.

More detailed discussions of the expected product modifications, and other factors leading to cost increases, appear in the following discussion. All cost estimates are expressed in 2014 dollars, for comparison with estimated benefits of the proposed rule.[114]

(1.) Electronic Fuel Injection (EFI)

The likely industry switch from engines with carburetors as the means of fuel delivery to closed-loop EFI is expected to be the most significant factor in determining cost increases under the proposed rule. This technology has been used for a number of years on the small spark-ignition engines in small motorcycles and scooters, as well as in more recent years in a variety of other product applications, including lawnmowers/tractors and golf carts. Although some firms have introduced portable generators with EFI for the consumer market in the last couple of years, generators with this fuel delivery system currently account for a very small fraction of sales. Associated components for closed-loop EFI could include the electronic control unit, fuel pump, injector(s), pressure regulator, throttle body, and a variety of sensors, such as

[113] Janet L. Buyer, Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator. U.S. Consumer Product Safety Commission, Bethesda, MD. September 2012.

[114] Cost estimates are adjusted to 2014 dollars by applying changes in the producer price index for riding lawn & garden equipment, a product group with similarities to portable generators.

manifold air pressure sensor or throttle position sensor, intake air temperature sensor, oil temperature sensor, crank position sensor, and related wiring and hardware, and an oxygen sensor for closed-loop feedback. According to the EPA, the combined costs of these elements for one-cylinder engines (which dominate the market for residential generators) are estimated to be about $90 per unit in 2014 dollars.[115] Cost savings of about $20 per unit are estimated for elimination of the carburetor, yielding estimated net costs of about $70 for the EFI components.

The effectiveness of EFI in controlling the air-fuel ratio with resulting improved engine combustion efficiency and reduced CO emissions was demonstrated by CPSC staff's technology demonstration project,[116] as well as by the EPA.[117] The EPA's demonstration work, which formed the basis of their 2008 analysis of more stringent requirements for HC and NO_X emissions of small non-road spark-ignition engines, provides a basis for our evaluation of this technology, specific to portable generators. The EPA estimates are largely consistent with other confidential estimates of costs provided by manufacturers of generators, as well as by a manufacturer of fuel-control components during discussions with CPSC staff.

Most CO poisoning deaths from portable generators occur when generators are used in enclosed spaces, such as in a closed garage, basement, or room in the living space of a house, or in a partially enclosed space, such as in a garage with the garage door opened part way.[118] In such scenarios, the spark-ignition engines are likely to be operating in conditions of decreasing oxygen concentrations in the ambient air. As noted previously, these conditions can make combustion less efficient, thereby increasing CO emission rates as the generators continue to operate, unless the reduced oxygen level is taken into account. CPSC's benefits analysis takes this into consideration by noting that both carbureted and closed-loop fuel-injected generators' CO emission rates increase as the oxygen in the intake air to the generator decreases.[119] In CPSC staff's view, compliance with these performance requirements would likely require the use of an oxygen sensor placed in the engine's exhaust stream to provide closed-loop feedback to the fuel-control system. The oxygen sensor sends a voltage signal to the electronic control unit that varies with the amount of oxygen in the engine exhaust. The ECU uses this signal to check that the correct amount of fuel is being metered through the fuel injector to maintain the air/fuel ratio at or near stoichiometry, which is the theoretical point for near-complete combustion and minimized CO emissions. The ECU uses the other sensors to determine how much fuel to provide, and the oxygen sensor provides feedback on whether or not the fuel mixture is correct. In this closed-loop operation, the ECU would continually adjust the fuel mixture to maintain complying CO emission rates. Based on information developed for EPA when its staff considered more stringent requirements for HC and NO_X emissions, engine manufacturers that incorporate oxygen sensors in the exhaust streams of portable generator engines could incur variable costs of about $10 per engine (adjusted to 2014 dollars).[120]

In its assessment of costs of this feature for small spark-ignition engines, the EPA (2006) also projected that Class I engines would also require batteries and alternators/regulators at estimated additional costs totaling about $17 (including original equipment manufacturer and warranty markups). As previously noted, data on shipments of portable generators for 2010 through 2014 show that portable generators with Class I engines comprised about 59 percent of units shipped, and those with Class II engines accounted for about 41 percent of units. Therefore, the estimated cost increase per unit for the EFI-related components identified in this section would be about $94 for generators with Class I engines (55% of units); about $79 for generators with one-cylinder Class II engines (about 36%); and about $85 for generators with two-cylinder Class II engines.[121]

We note that it may be technically feasible, and perhaps eventually less costly for manufacturers to incorporate EFI systems that power-up the fuel pump and electronic components by magnets when starter cords are pulled. Battery-less EFI systems have been available in consumer products for several years, including snowmobiles, outboard motors, and motorcycles. However, we are not aware of the current use of this technology in applications with Class I engines. Comments on prospective use (*e.g.,* costs, applicability and challenges) of battery-less EFI for portable generators would be welcome.

(2.) Catalysts in Mufflers

Generator manufacturers also are likely to include three-way catalysts[122] in the mufflers of generator engines to achieve the low CO emission rates that would be required by the proposed standard, and still allow compliance with EPA Phase 3 emissions standards for other pollutants in ES staff's judgment.[123] Catalysts assist in chemical reactions to convert harmful components of the engine's exhaust stream (Hydrocarbons [HC] and oxides of nitrogen [NO_X] in addition to CO) to harmless gases. According to the Manufacturers of Emission Controls Association (MECA), the catalysts perform this function without being changed or consumed by the reactions that take place. In particular, when installed in the exhaust stream, the catalyst promotes the reaction of HC and CO with oxygen to form carbon dioxide and water, and the chemical reduction of NO_X to nitrogen is caused by reaction with CO over a suitable catalyst.[124]

In its assessment of the costs of the Phase 3 emission standards for small SI engines, EPA estimated that 3-way catalysts in mufflers of one-cylinder engines of portable generators could add about $10 to $20 in additional hardware costs to the manufacturing costs per engine, depending on capacity, power, and useful life.[125] These estimates were

[115] U.S. Environmental Protection Agency (EPA), (2006, July). Small SI engine technologies and costs, final report. Prepared by Louis Browning and Seth Hartley, ICF International, for the Assessment and Standards Division, Office of Transportation and Air Quality, EPA. Washington, DC. These cost estimates include original equipment manufacturer markups and warranty markups totaling an estimated 34 percent; such markups were also included in EPA's cost estimates.

[116] Janet L. Buyer, Technology Demonstration of a Prototype Low Carbon Monoxide Emission Portable Generator. U.S. Consumer Product Safety Commission, Bethesda, MD. September 2012.

[117] McDonald, Joseph, Olson B, and Murawski M, Demonstration of Advanced Emission Controls for Nonroad SI Class II Engines, SAE paper 2009–01–1899.

[118] Tab A of the staff's briefing package.

[119] See Tabs I and K of the staff's briefing package.

[120] U.S. Environmental Protection Agency (EPA) (2008, September). Control of emissions from marine SI and small SI engines, vessels, and equipment: Final regulatory impact analysis. Assessment and Standards Division, Office of Transportation and Air Quality. Washington, DC. Page 6–22; As with EFI cost estimates, this per-unit cost estimate related to oxygen sensors includes original equipment manufacturer and warranty markups totaling 34 percent.

[121] Two-cylinder engines would require two fuel injectors, which increases costs versus one-cylinder Class II engines.

[122] Three-way catalysts are designed to simultaneously convert three pollutants to harmless emissions: Carbon Monoxide → Carbon Dioxide; Hydrocarbons → Water, and; Oxides of Nitrogen → Nitrogen.

[123] Tab I of staff's briefing package.

[124] Manufacturers of Emission Controls Association (MECA) (2009, January). White Paper: Emission control of small spark-ignited off-road engines and equipment. Washington, DC. Retrieved from: *http://www.meca.org/galleries/files/sore_white_paper_0109_final.pdf*.

[125] EPA, *op. cit.*

based on assumptions regarding use of precious metals (principally platinum and rhodium), which were not formulated to oxidize CO, and their prices in 2005. Based on our analysis of costs, including heat shields or double-walled mufflers that could be necessary, catalytic mufflers could add about $14 to the manufacturing cost of a Class I engine and about $19 to the cost of a Class II engine. These costs could vary, depending on choices and assumed loadings of precious metals. Recent evaluations of nonprecious metal catalysts by MECA have found that these less-costly catalysts perform well in the oxidization of CO.[126] Application of this technology could lead to a reduction in costs of compliance related to catalytic after-treatment.

Although EPA assumed that Class I and Class II engines would include catalytic mufflers under Phase 3 emission requirements, a majority of small SI engines submitted for EPA certification in recent years has not included after-treatment devices, such as catalysts. Current engines produced with catalytic after-treatment would incur smaller costs for this feature. In the view of CPSC engineering staff, portable generators powered by 4-stroke handheld engines might not require catalysts to comply with the proposed rule since the catalyst in both CPSC's and EPA's demonstration programs was primarily for NO_X reduction, and handheld engines have less stringent NO_X emission requirements under EPA emission standards.[127] For purposes of estimating costs, we assume that catalyst-related costs for generators with handheld engines would average 50 percent of estimated costs for units with Class I engines, or about $7 per generator.

(3.) Design and Development/Other Reengineering

In an analysis of small SI engine technologies and costs, ICF International estimated that costs of conversion to EFI from carburetors would require 4 months of design time (engineers) and 6 months for development (by engineers and technicians) for Class I engines and 2 months for design and 2 months for development for Class II engines).[128] Based on estimated labor costs for engineering/technical staff, EPA estimated that these design and development costs totaled about $175,000 for Class I engines and about $64,000 for Class II engines, for each engine family. Design and development costs for three-way catalysts in mufflers were estimated by EPA to be about $135,000 per engine line for 2 months of design time (engineers) and 5 months of development time (engineers and technicians). Adjusting for changes in an appropriate producer price index, the total design and development costs for engines to incorporate EFI and catalysts are estimated to be about $316,000 for a Class I engine family and $203,000 for a Class II engine family. We assume (as EPA did) that these costs are recovered over 5 years. If average annual production per-engine family ranges from 10,000 to 50,000 units, per-unit design and development costs could range from about $1 to $6 for Class I engines and under $1 to about $4 for Class II engines.

These estimated costs could be applicable for portable generator manufacturers that supply their own engines. Engine manufacturers that supply engines to independent generator manufacturers might successfully pass along research and development costs with markups. EPA estimated that manufacturing and warranty markups by suppliers of EFI and catalytic components total 34 percent. Similar markups of design and development costs by suppliers of complying engines could increase generator manufacturing costs by about $2 to $8 for generators with Class I engines and by about $3 to $5 for generators with Class II engines. Manufacturers of approximately 80 percent of generators supply their own engines. Therefore, average generator manufacturing costs for design and development could be about $4.05 for generators with Class I engines and $2.60 for generators with Class II engines.[129]

Costs of design and development for generators powered by handheld engines were not specifically addressed by EPA. For the purposes of this preliminary analysis, we assume that these costs will be similar to those estimated for units with Class I engines. However, we assume that costs per engine family would be apportioned over perhaps 5,000 to 10,000 units annually. This assumption leads to average generator manufacturing costs for design and development of about $10 per unit for generators with handheld engines. We also acknowledge that models with handheld engines often are valued and promoted for their compactness and light weight. Accommodating new features that might be necessary for compliance with the proposed rule and still provide these desired product characteristics could present greater challenges and costs for product engineers and firms. The Commission welcomes comments on this issue, as well as on components and technologies that might be available to meet these challenges and moderate the impacts of the proposed rule on these models.

Costs of new designs and tooling may also be required for generator frames and housings to accommodate additional components, such as batteries for generators with Class I engines, and to address reported concerns with heat dissipation. Modifications could be minimal for many larger generators with open-frame designs; but some smaller units with housings that enclose engines and other components could require larger, redesigned housings, at greater cost. We have assumed that per-unit tooling costs for generators with handheld engines would be twice that of other generators, but costs may be underestimated for small generators. The Commission welcomes comments on this issue from firms that would be affected by the rule.

The modifications to small SI engines to comply with the CO emission requirements of the CPSC standard would likely require engine manufacturers to seek certifications (as new engine families) under EPA requirements for $HC+NO_X$ and CO, with the attendant costs for fees and testing, which could be passed on to generator manufacturers that purchase the engines to power their products. Some of the larger manufacturers of portable generators are vertically integrated firms that also manufacture the engines that power their products. It is possible that engine modifications by engine manufacturers (including firms that also manufacture generators) to comply with the CPSC emission standards for CO could result in emissions of $HC+NO_X$ that are consistently lower than the EPA emission requirements. This potential effect of the use of EFI and catalysts was shown by demonstration programs sponsored by CPSC (conducted by the University of Alabama) and EPA, as detailed in the CPSC staff's technical rationale for the proposed standard.[130] Consistently lower emission rates for $HC+NO_X$ could result in ''engine credits'' for engine families under EPA's

[126] Kevin Hallstrom. ''Catalyst control of CO from portable generators.'' Presentation on behalf of Manufacturers of Emission Controls Association (MECA) at the PGMA Technical Summit, March 17, 2016. Available online (pp. 125–141) at: *http://www.cpsc.gov//Global/Newsroom/FOIA/Meeting%20Logs/2016/MeetingLogPGMA31716.pdf.*

[127] Tab I of staff's briefing package.

[128] EPA (2006), *op. cit.*

[129] Midpoint estimates for annual engine family production ranging from 10,000 to 50,000 units.

[130] Tab I of the staff's briefing package.

program for averaging, banking and trading (ABT) of emission credits. If manufacturers of engines participate in the ABT program, they could partially offset increased manufacturing costs of compliance with the proposed CPSC standard, and some of these savings could moderate the engine cost increases incurred by generator manufacturers that do not make their own engines.

(4.) Testing and Certification

The proposed rule does not prescribe a particular test that manufacturers must use to assess compliance with the performance requirements. Instead, the proposed rule includes the test procedure and equipment that CPSC would use to assess compliance with the applicable performance requirements of the standard.[131] Manufacturers need not use the particular test referenced by the proposed rule, although whatever test is used must effectively assess compliance with the standard. We have assigned minor costs per unit for this element in Table 12, but we welcome comments on this issue.

b. Other Potential Costs

Evaluation of more stringent emission standards by the EPA found that pressurized oil lubrication systems for engines would be among the engine design changes. EPA's assessment of this engine feature is that it results in ''enhanced performance and decreased emissions'' because it allows better calibrations and improved cooling potential.[132] Based on estimates made for EPA, variable costs for a pressurized oil system would be about $19 for small spark-ignition engines that now lack this feature. In the view of the Directorate for Engineering Sciences, pressurized lubrication systems would not be necessary to comply with the draft standard. We welcome comments on this issue.

c. Total Costs,per Unit

Aggregate estimated compliance costs to manufacturers of portable generators average approximately $113 per unit for engine and muffler modifications necessary to comply with the CO emission requirements of the proposed standard. Cost elements by engine class and characteristics are shown in Table 12.

Table 12.

Net Estimated Manufacturing Costs[1] per Unit to Comply with the Proposed Standard CO Emission Requirements[2]

Cost Elements	Handheld Engines	Class I Engines	Class II Engines	
			1-Cylinder	2-Cylinder
EFI-Related Costs[3]	$67	$67	$69	$75
Oxygen Sensor for Closed-Loop	$10	$10	$10	$10
Battery and Alternator/Regulator[4]	$17	$17	n/a	n/a
Catalyst-Related Costs	$7	$14	$27	$49
Research and Development	$10	$4	$3	$3
Tooling Costs	$4	$2	$2	$2
Testing and Certification	< $1	< $1	< $1	< $1
Combined Compliance Costs	$114	$113	$110	$138

[1] Costs expressed in 2014 dollars, rouonded to the nearest dollar.

[2] Estimates are for overhead valve (OHV) engines, which comprise nearly all engines used in the manufacture of portable generators

[3] Net, less costs related to carburetors.

[4] For those generators with handheld and Class I engines which currently do not have batteries.

(1.) Implications for Retail Prices and Consumer Demand

In addition to the direct costs of the rule, increases in the retail price of portable generators (as costs are passed forward to consumers) are likely to reduce sales. Additionally, consumers who no longer purchase portable generators because of the higher prices will experience a loss in utility that is referred to as consumer surplus, but is not included in the direct cost estimates described in the last section. These impacts are illustrated conceptually in Chart 4 below. For purposes of this analysis, we assume that cost increases are pushed forward to consumers.

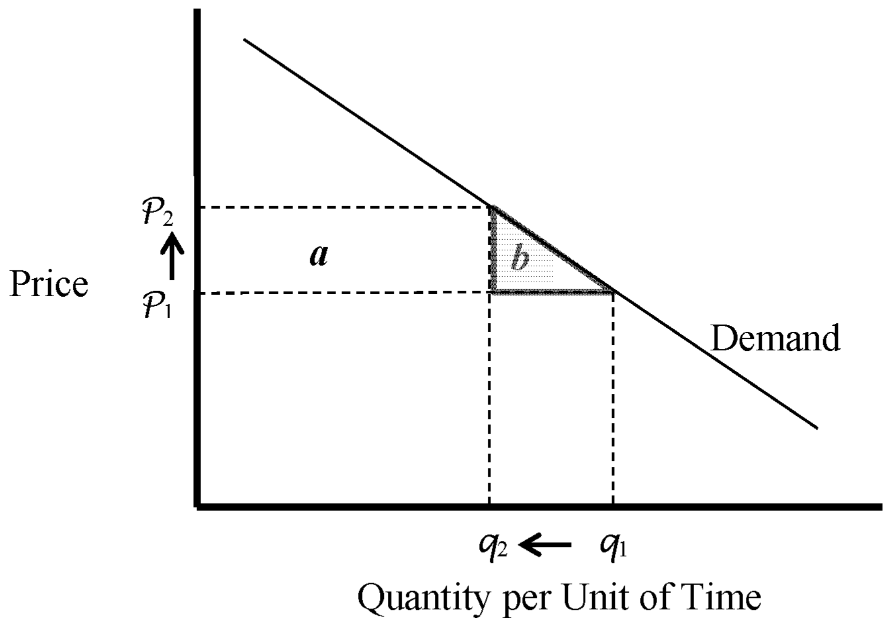
The downward sloping curve in Chart 4 represents the demand for generators; p_1 and q_1 represent the preregulatory price and quantity of generators demanded. After the regulation becomes effective, generator prices rise to p_2, and

[131] *i.e.,* Weighted CO emission rates emitted from the generator when operating in normal oxygen: 75 g/h for generators with handheld and Class I engines; 150 g/h for generators powered by one-cylinder Class II engines; and 300 g/h for generators powered by two-cylinder Class II engines.

[132] EPA (2006), *op. cit.*

the quantity of generators demanded declines to q_2. The value of $p_2 - p_1$ represents the direct costs of the rule per generator (*e.g.,* $113 for those with Class I engines and $138 for two-cylinder Class II generators). The area given by the rectangle *a* represents the aggregate annual direct costs of the rule, which is equal to the product of the increase in portable generator price ($p_2 - p_1$) and the post-regulatory quantity demanded (*i.e.,* q_2). The triangle *b* represents additional costs of the rule in the form of a loss in consumer surplus: A value over and above what consumers paid for the product prior to the regulation, but that is lost to the consumers who do not purchase a generator at the higher price, p_2.

Chart 4.
Demand for Portable Generators



Given information on the pre-regulatory price (p_1) and quantity demanded (q_1), the impact of the rule on product prices, and information on the elasticity of demand for portable generators (*i.e.,* the percentage change in quantity demanded given a percentage change in price), we can make an estimate of the expected reduction in sales ($q_1 - q_2$), and the lost consumer surplus represented by triangle *b* in Chart 4. Based on information presented earlier, estimated preregulatory (current) sales (*i.e.,* q_1) consist of about 15,000 generators with handheld engines; about 801,000 generators with non-handheld Class I engines; about 504,000 generators with one-cylinder Class II engines; and about 65,000 generators with two-cylinder Class II engines. Preregulatory retail prices of portable generators (p_1) average about $324 for generators with handheld engines; $534 for generators with non-handheld Class I engines; $1,009 for generators with one-cylinder Class II engines; and $2,550 for generators with two-cylinder Class II engines.[133]

We are not aware of precise estimates of the price elasticity of demand for portable generators; however, the nature of the product could argue for a relatively inelastic demand: Sales of the product often peak when consumers need or anticipate the need for backup power for small and major appliances (*e.g.,* during weather-related outages, anticipated Y2K outages). In these circumstances price may not be a significant determinant for many purchasing decisions. Based on available estimates of the price elasticity of demand for household appliances (for example: −0.23, by Houthakker & Taylor,[134] and −0.35, for refrigerators, clothes washers and dishwashers, by Dale & Fujita, 2008 [135]), the price elasticity for portable generators could be approximately −0.3. If this relationship between price increase and consumer demand holds true for complying portable generators marketed under the proposed rule, a 1.0 percent increase in price for generators would result in a 0.3 percent reduction in unit demand.

Given these parameters, the quantity demanded might decline by about 11 percent ($\$114/\$324 \times -0.3$), on average, for generators with handheld engines (reducing sales from about 15,000 to about 13,400 annually); by an average of about 6 percent ($\$113/\$534 \times -0.3$) for generators with non-handheld Class I engines (projected to reduce sales from about 801,000 to about 750,000 annually); by about 3 percent ($\$110/\$1,009 \times -0.3$) for generators with one-cylinder Class II engines (projected to reduce sales from about 504,000 to about 487,000); and by about 1 percent ($\$138/\$2,550 \times -0.3$) for generators with two-cylinder Class II engines

[133] Based on an October 2015 survey of retail prices of more than 350 portable generators as reported on Internet sites of six retailers.

[134] Houthakker, H.S. and Taylor, L. (2010). Consumer demand in the United States: Analyses and projections, 2nd edition. Cambridge, MA: Harvard University Press.

[135] Dale, L. and Fugita, K.S. (2008, February). An analysis of the price elasticity of demand for household appliances. Energy Analysis Department, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, University of California. Berkeley, CA.

(projected to reduce sales from about 65,000 to 64,000). As noted in our discussion of retail price information, factors other than engine capacity or generator power affect retail prices; and lower-priced generators with each engine class/category would be expected to face a relatively greater price increase under the proposed rule, and correspondingly, a greater decrease in consumer demand. In general, we would anticipate that generators without features that increase price, such as inverter technology, would realize a more significant percentage impact on manufacturing costs, retail prices and consumer demand, at least initially. Price increases for new generators that would comply with the standard could lead more consumers to repair their older units or to purchase used units on the secondary market. Additionally, price increases for larger portable generators could lead more consumers to purchase stationary, standby generators for use during power outages.

The value of lost consumer surplus resulting from increased prices under the proposed rule (represented by the area of triangle *b* in Chart 4) could be about $4 million annually; comprised of about $90,000 for generators with handheld engines; $2.9 million for generators with Class I engines; about $910,000 for generators with one-cylinder Class II engines; and about $70,000 for generators with two-cylinder Class II engines.

(2.) Combined Direct Costs and Lost Consumer Surplus per Unit

If the estimate of lost consumer surplus is spread over the remaining units sold, the estimated costs, per product sold, might average about $6.78 for generators with handheld engines ($91,000 ÷ 13,400 units); $3.85 for generators with Class I engines ($2,889,000 ÷ 750,000 units); $1.88 for generators with one-cylinder Class II engines ($914,000 ÷ 487,000 units); and $1.14 for generators with two-cylinder Class II engines ($73,000 ÷ 64,000 units). If these per-unit costs of lost consumer surplus are combined with the direct manufacturing costs estimated previously in this section, the total estimated per-unit costs would amount to about $121 for generators with handheld engines; $117 for generators with Class I engines; $112 for generators with one-cylinder Class II engines; and about $139 for generators with two-cylinder Class II engines. These are the cost figures that will be compared to the expected benefits of the rule.

It is possible, however, that some consumers might perceive greater value for complying generators, in terms of fuel efficiency, greater ease of starting, product quality and safety. These perceptions could moderate the adverse impact on demand (*i.e.,* reduced sales) resulting from price increases.

1. Comparison of Benefits and Costs

Table 13 presents both the estimated benefits (Row 1) and the estimated costs (Row 2) of the proposed rule. The expected per-unit benefits were derived in Table 5; they average about $243 for generators with handheld engines; $254 for generators with Class I engines; $214 per unit for generators with one-cylinder Class II engines, and; $4 for generators with two-cylinder Class II engines. The estimated $4 in benefits for the two-cylinder Class II engines reflects the fact that very few consumer deaths have involved these generators in the scenarios modeled by NIST and analyzed by CPSC staff, perhaps because they are less likely to be brought indoors because of their size and weight or loudness during operation. Additionally, given the limits on CO emissions for those generators, only about 17 percent of the addressable societal costs are projected to be prevented by the proposed rule.

The costs, including both manufacturing compliance costs (from Table 12), and the costs associated with lost consumer surplus (from the previous section), amount to $121 for generators with handheld engines; $117 for generators with Class I engines; $112 for generators with one-cylinder Class II engines; and about $139 for generators with two-cylinder Class II engines.

As shown in Row 3, the proposed CO emission standard is estimated to result in net benefits (*i.e.,* benefits minus costs) of about $122 per unit for generators with handheld engines ($243–$121); $137 per unit for generators with Class I engines ($254–$117); about $101 for generators with one-cylinder Class II engines ($214–$112); and approximately −$135 for generators with two-cylinder Class II engines ($4–$139).

Projected annual unit sales under the proposed standard are shown in Row 4. Finally, Row 5 shows aggregate net benefits based on the product of net benefits per unit (Row 3) and product unit sales (Row 4).

An examination of Row 5 indicates that aggregate net benefits would be maximized at about $153 million annually, if only handheld engines, Class I engines, and one-cylinder Class II engines are covered by the proposed rule. Including the two-cylinder Class II engines under the standard would reduce aggregate net benefits to about $145 million. Rather, under the CPSA, the benefits of the rule must bear a reasonable relationship to its costs, and the rule must impose the least burdensome requirement that prevents or adequately reduces the risk of injury. 15 U.S.C. 2058(f)(3)(E) and (F).

Hence, the preliminary regulatory economic analysis suggests that excluding the portable generators with two-cylinder Class II engines from the rule would maximize net benefits, an outcome that would be consistent with OMB direction but not required under the CPSA. Generators with these larger and more powerful engines accounted for just 0.4 percent of the 503 consumer CO poisoning deaths addressed by the simulation analysis performed by NIST and the benefits analysis performed by CPSC staff (Hnatov, Inkster & Buyer, 2016). Portable generators with two-cylinder engines are estimated to have comprised about 7 percent of units in use over 2004 to 2012 (as shown in Tables 9 & 10) and about 5 percent of unit sales in recent years (Table 11).

Table 13.
Aggregate Estimated Present Value of Benefits and Expected Costs Resulting from the Proposed Standard, for Annual Unit Shipments, by Generator Engine Class

	Handheld Engines	Class I Engines	Class II Engines		All Units
			1-Cylinder	2-Cylinders	
Present Value of Expected Benefits / Unit	$243	$254	$214	$4	$227
Costs to Manufacturers + Lost Consumer Surplus / Unit	$121	$117	$112	$139	$116
Net Benefits / Unit	$122	$137	$101	-$135	$110
Projected Annual Unit Sales Under the Standard	13,410	749,504	487,026	63,765	1,313,705
Aggregate Net Benefits from Annual Sales (Million $)	$1.6	$102.3	$49.3	-$8.6	$144.6

As discussed previously, the analysis was limited to the 503 out of 659 CO poisoning deaths during the period 2004 through 2012. Commission staff reports that there could be some unquantified benefits associated with 156 deaths not modeled by NIST.[136] However, this would not change the main findings of our analysis. If there were some additional deaths involving generators with handheld, Class I, or one-cylinder Class II engines that would have been prevented, our estimated net benefits for these generator classes would increase somewhat. On the other hand, even if all of the deaths involving generators with two-cylinder Class II engines would have been prevented, the costs for this class of generators would have exceeded the benefits.

Additionally, one underlying assumption for the benefits estimate is that there would be no behavioral adaptations by consumers in response to the reduced rate of CO emissions from portable generators. Knowledge about reduced CO emissions from generators produced under the proposed rule could reduce consumers' perceptions of injury likelihood and susceptibility, which, in turn, could affect consumer behavior.[137] In economic terms, the proposed rule could reduce what we might call the cost or risk-price of unsafe behavior, and implicitly provide an incentive for consumers to increase that behavior. If consumers are aware of the reduced CO poisoning risk, and the rule does not make it more difficult to operate generators indoors, it seems likely that there would be some increase in warned-against practices. For example, some consumers might reduce the distance between their house and the generator because they think closer proximity of the generator to the house will reduce the likelihood that the generator will be stolen. Similarly, to keep the generator out of the elements, some consumers who had run their generator outside might decide to bring it into the garage. Additionally, some consumers might even decide to run the generator inside their home. Behavioral adaptation as a potential effect of the rule is discussed by CPSC's Division of Human Factors (HF) (Smith, T., 2016). We cannot quantify this impact, and for reasons cited by HF, it could be small. However, while the proposed rule will significantly increase the safety of generators from an engineering standpoint, it seems likely that the increased technical safety predicted by modeling under the assumption of no behavioral adaptation will be partially be offset by the behavioral adaptations of some users.

F. Sensitivity Analysis

The benefit-cost analysis presented above compares benefits and costs of our base-case analysis. In this section, we present a sensitivity analysis to evaluate the impact of variations in some of the important parameters and assumptions used in the base-case analysis. Alternative inputs for the sensitivity analysis included:

- Shorter (8 years) and longer (15 years) expected product-life estimates than the 11 years used in the base analysis;
- A discount rate of 7 percent, rather than 3 percent, to express societal costs and benefits in their present value;
- Compliance costs and lost consumer surplus per-unit that are 25 percent higher than the base analysis;
- Lower ($5.3 million) and higher ($13.3 million) values of a statistical life (VSL) than the $8.7 million value for the base analysis; and
- Lower (by 25%) and higher (by 25%) effectiveness for each engine class and characteristic at reducing societal costs of CO poisoning.

The results of the sensitivity analysis are presented in Table 14, with Part A showing estimated net benefits per unit for generators in our base-case analysis (from Table 13) for each engine class and type, and Part B presenting the estimated net benefits per unit, using the alternative input values.

Variations in the expected product life had a relatively small impact on net benefits; a reduced expected product life decreased expected net benefits slightly, while an increased expected product life increased net benefits (rows a and b).

OMB (2003) recommends conducting a regulatory analysis using a 3 percent and 7 percent discount rate.[138] Because

[136] See Tab K of the staff's briefing package.

[137] This potential effect of knowledge about improvements in safety has been addressed in human factors literature, such as the article by Leonard Evans in "Human Behavior Feedback and Traffic Safety," published in Human Factors: The Journal of the Human Factors and Ergonomics Society, 27(5), 555–576. January 1985.

[138] Our base analysis discount rate is consistent with research suggesting that a real rate of 3 percent is an appropriate discount rate for interventions involving public health (see Gold, M., Siegel, J.,

Continued

of the relatively long product life of generators, using a 7 percent discount rate substantially reduced estimates of net benefits for the first three generator categories, but they remained positive (row c). However, because benefits were so small for the units with 2-cylinder Class II engines, the impact of the 7 percent discount rate on this category was negligible.

Variations in cost estimates would directly impact our estimates of net benefits. Discussions with generator and engine manufacturers suggest that the EPA cost estimates, upon which our analysis was based, may have led to underestimates of the incremental costs of EFI and other components that would be needed for the proposed rule. However, the results of this sensitivity analysis show that even if we had systematically underestimated the costs of the proposed rule by 50 percent, the findings of the analysis would have remained unaltered: Generators with handheld, Class I, and one-cylinder Class II engines would continue to exhibit positive net benefits.

Finally, we considered the impact of variations in the value of statistical life (VSL) on the results of the analysis. Kniesner, Viscusi, Wook and Ziliak (2012) suggested that a reasonable range of values for VSL was between $4 and $10 million (in 2001 dollars),[139] or about $5.3 million to $13.3 million in 2014 dollars. Consequently, we evaluated the sensitivity of our results to variations in the VSL by applying these alternative VSLs (rows e and f). This variation had a substantial impact on the estimated net benefits (as would be expected given deaths account for the great majority of generator-related societal costs). Nevertheless, the variations in VSL did not affect the results of the analysis.

In summary, for each variation analyzed, the overall estimated net benefits of the proposed standard were found to remain positive for the first three categories of generators. However, as with the base-case analysis, the sensitivity analysis showed that generators with two-cylinder Class II engines had estimated costs that remained substantially greater than the present value of projected benefits.

Table 14. Sensitivity Analysis: Expected Net Benefits Associated with Variations in Inputs

Part A: Base-Case Results.*

Row	Input Value	Net Benefits per Generator, by Portable Generator Engine Class/Type			
		Handheld	Class I	1-cylinder Class II	2-cylinder class II
A	Base Case Analysis	$122	$137	$101	−$135

* Base-Case Inputs:

- 3% discount rate;
- Portable Generators in Use: 10.3 million.
- VSL = $8.7 million per statistical life
- Expected product life: (years), 11 years
- Compliance Costs & Lost Consumer Surplus per unit ranging from $112 – $139
- Estimated reduction in addressable deaths (and injuries) ranging from ≈ 17% for 2-cylinder Class II engines to ≈ 49% for Class I engines

Russell, L. and Weinstein, M., eds. (1996). *Cost-effectiveness in health and medicine.* New York: Oxford University Press); a 3 percent discount rate (along with a 7 percent discount rate) is also recommended for regulatory analyses by the Office of Management and Budget (OMB, 2003).

[139] Kneiser, Viscusi, Wook & Ziliak (2012). The value of a statistical life: Evidence from panel data. *The Review of Economics and Statistics, 94*(1), 74–87.

Table 14. Part B: Alternative Inputs for Sensitivity Analysis

Row	Input Variable and Value(s) Used in Sensitivity Analysis	Net Benefits per Generator, by Portable Generator Engine Class/Type			
		Handheld	Class I	1-cylinder Class II	2-cylinder Class II
Base Case Analysis:		**$122**	**$137**	**$101**	**−$135**
Expected Product Life					
A	Shorter Expected Product Life: 8 years	$107	$121	$88	−$135
B	Longer Expected Product Life: 15 years	$144	$161	$124	−$134
Discount Rate					
C	7% discount rate	$66	$78	$52	−$136
Costs Estimates					
D	50% higher than base-case for each engine class/type	$61	$78	$45	−$204
Value of a Statistical Life					
E	Lower VSL: $5.3 million	$48	$60	$36	−$136
F	Higher VSL: $13.3 million	$221	$241	$189	−$133
Effectiveness at Reducing Deaths & Injuries					
G	Lower Effectiveness: 25% lower than estimated	$62	$75	$49	−$136
H	Higher Effectiveness: 25% higher than estimated	$185	$202	$157	−$134

G. Regulatory Alternatives

In accordance with OMB (2003) guidelines to federal agencies on preparation of regulatory impact analyses, the Commission considered several regulatory alternatives available to the Commission that could address the risks of CO poisoning from consumer use of portable generators. The alternatives considered included: (1) Establishing less-stringent (higher allowable) CO emission rates; (2) excluding generators with Class II, two-cylinder engines from the scope of the rule; (3) an option for reducing consumer exposure to CO by using an automatic shutoff; (4) establishing later compliance dates; (5) relying upon informational measures only; and (6) taking no action.

1. Less Stringent (Higher Allowable) CO Emission Rates

Cost savings from higher allowable CO emission rates might result from lower costs associated with catalysts (if they would not be required, or if less costly materials could suffice), less extensive engine modifications (other than EFI-related costs) and less extensive generator-housing modifications (if housing enlargement and other retooling would be minimized). For example, CPSC staff's report presenting the technical rationale for the proposed standard speculates that 4-stroke handheld engines might not need a catalyst,[140] and in our base-case estimate of catalyst-related costs for generators with handheld engines, we assumed an average of 50 percent of the estimated costs for units with Class I engines, or about $7 per unit. A less stringent emission standard could allow more units with handheld engines, and perhaps some with smaller Class I engines, to comply without catalytic after-treatment.

Expected reductions in societal costs from CO poisoning in scenarios analyzed by the Commission could be about 30 percent for units with handheld engines; about 36 percent for units with Class I engines; about 30 percent for generators with 1-cylinder Class II engines; and about 11 percent for generators with 2-cylinder Class II engines. We estimate that these reductions in societal costs would be reflected in decreased present value of benefits per unit of nearly $90 for generators with handheld engines (a decrease of 36%); about $70 for generators with Class I engines (−28%); and about $40 for units with 1-cylinder Class II engines (− 18%). It seems likely that cost savings from less stringent CO emission requirements would be less than expected reductions in benefits. Therefore, net benefits of the rule would probably decrease under this regulatory alternative.

The Commission did not consider a more stringent alternative because CPSC engineering staff believes that the rates in the proposed rule are based on the lowest rates that are technically feasible. Comments providing information on the benefits and costs that would be associated with different CO emission rates would be welcome.

2. Alternative Scope: Limiting Coverage to One-Cylinder Engines, Exempting Portable Generators With Two-Cylinder, Class II Engines From the Proposed Rule

The Commission could exempt portable generators with two-cylinder Class II engines from the requirements of the proposed rule. As shown in the base-case analysis, the gross benefits that would be derived from including this class of portable generators within the requirements of the standard would only amount to about $4 per unit. There are two reasons for the small per-unit benefit estimate. First, while generators with two-cylinder Class II engines accounted for 7.1 percent of generators in use during the 2004 through 2012 study period, they accounted for only about 1.2 percent of deaths. Consequently, the relative risk for generators with two-cylinder Class II engines was only about 16 percent of the risk for the handheld and one-cylinder models. Second, the analysis of benefits of the proposed emission limits for generators with two-cylinder Class II engines (300 g/hr at unreduced ambient oxygen levels) suggests that the proposed rule would only prevent about 17 percent of the addressable deaths for this class of generators (Hnatov, Inkster & Buyer, 2016).[141]

The costs of the proposed rule are estimated to amount to $139 per two-cylinder, Class II generator, yielding *negative* net benefits of about $135 ($4 in benefits—$139 in costs) per unit. Given annual sales of about 64,000 units, the aggregate net benefits associated with this class of generators would amount to about −$8.6 million (64,000 generators × $135 per generator) annually. In other words, excluding this class of generators from the requirements of the proposed rule would increase the net benefits of the rule by about $8.6 million annually, to approximately $153 million. We also note that the total estimated value of expected societal costs of CO poisoning deaths and injuries per unit, including those *not* addressed by the staff's epidemiological benefits analysis, is $116 per unit (as shown in Tables 5 & 6); hence, even if all of the deaths attributed to generators with two-cylinder Class II engines were to be prevented by the proposed rule standard, the costs would exceed the benefits for these generators.

Exclusion of generators with two-cylinder engines from the scope of the rule could create an economic incentive for manufacturers of generators with larger one-cylinder engines to either switch to two-cylinder engines for those models, or if they already have two-cylinder models in their product lines, they could be more likely to drop larger one-cylinder models from their product lines. The precise impacts of such business decisions on aggregate net benefits of the rule are not known at this time, but it would likely be of marginal significance. We have no evidence that such substitution would occur or, even if it did, that the impact would be significant. Moreover, the higher cost of manufacturing the two-cylinder generators could offset any cost advantage that would result by avoiding the requirements of the proposed rule.

If it would be technologically feasible and cost-effective for manufacturers to use smaller two-cylinder engines for generators in lower power ratings that are associated with greater per-unit societal costs, the reduction in scope of the rule might also specify a minimum engine displacement. For example, if this issue were a concern to the Commission, it could exempt generators with two-cylinder engines, but only if the two-cylinder models had a displacement above a specified value of total engine displacement.

The Commission is including class 2 twin-cylinder generators in the scope of the proposed rule and seeks comments and input on whether class 2 twin-cylinder generators should be excluded from the scope and input on possible shifts in the market of generators powered by two-cylinder engines, such as those discussed above, that might result if two-cylinder generators were excluded from the scope of the rule. The Commission seeks comments on what an appropriate limit on displacement would be if generators with two-cylinder engines above a certain displacement were excluded from the scope, to avoid creating a market incentive for small twin-cylinder generators that avoid the scope of the proposed rule.

3. Alternate Means of Limiting Consumer Exposure: Automatic Shutoff Systems

CPSC staff considered options for reducing the risk of CO poisoning that would require portable generators to shut off automatically if they sensed that a potentially hazardous situation was developing, or if they were used in locations that are more likely to result in elevated COHb levels in users. CPSC engineering staff evaluated four shutoff strategies/technologies: (1) A generator-mounted CO-sensing system, which would (ideally) sense higher CO levels during operation indoors and shut off the engine before dangerous levels build up; (2) a CO-sensing system located away from the generator (*e.g.,* inside the dwelling) that relies on the user to properly place the sensing unit in a location where it can communicate with the generator and send a signal remotely, causing the engine to shut down; (3) a generator-mounted global-positioning (GPS) system intended to infer operation of the generator indoors (from detection of reduced satellite signal strength) and automatically shut down the engine; and (4) applicable to generators equipped with EFI, an

[140] See Tab I of the staff's briefing package.

[141] See Tab K of the staff's briefing package.

algorithm programmed into the engine control unit (ECU) that relies on system sensors to infer indoor operation, signaling the ECU to shut down the engine. The findings of the CPSC engineering evaluation reports on each of the shutoff strategies are summarized in detail in the briefing memorandum for the proposed rule.

As alternative means of limiting exposure to CO, automatic shutoff systems could be incorporated into a standard that limits CO production per hour (such as the draft proposed standard), or they could enable compliance with an alternative standard that requires generators to shut off automatically if they are used in conditions that could lead to accumulation of hazardous levels of CO. Allowing the use of automatic shutoff systems, as either a supplement to limits on CO production per hour or under an alternative shutoff standard could potentially be less costly for manufacturers, and result in greater reductions in CO poisoning for consumers.

However, CPSC staff does not believe that an automatic shutoff standard or option is sufficiently proven to be feasible at this time. As noted, CPSC engineering staff investigated four different approaches for an automatic shutoff system, and was not able to demonstrate how any of the shutoff systems could be implemented satisfactorily. Unresolved concerns with the automatic shutoff technologies studied by CPSC staff include: (1) Possibly creating a false sense of safety, which could lead to increased use of portable generators indoors; (2) alternatives that require CO sensors falsely could identify hazards, which would detrimentally affect the utility of the generator when used in proper locations, and could lead to consumers overriding the mechanism; (3) the system would have to be shown to be durable and capable of functioning after being stored for long periods and being used under widely different conditions; and (4) use of algorithms to shut off engines with ECUs would have to be engine-specific and tailored to each engine function, requiring a significant amount of additional testing on this system. These concerns would have to be resolved before a standard incorporating an automatic shutoff option could be developed.

4. Different (Longer) Compliance Dates

As noted in the technical rationale for the proposed rule, staff believes that 1 year is sufficient lead time for manufacturers to implement the necessary modifications on both one-cylinder and two-cylinder Class II engines powering generators.[142] This assessment is partly based on greater industry experience in manufacturing small engines with closed-loop EFI for a variety of applications, including portable generators, since 2006, when the EPA estimated that manufacturers would need 3 years to 5 years to implement closed-loop EFI and make necessary engine improvements, if EPA were to adopt more stringent requirements for its HC+NO_X emission standard for small SI engines. Because of the experience gained by engine manufacturers in recent years, the Commission thinks 1 year from the date of publication of the final rule would provide an appropriate lead-time for generators powered by Class II engines. The Commission is proposing a later compliance date that would take effect 3 years from the date of publication of the final rule for generators powered by smaller engines (handheld and Class I engines). This longer period addresses manufacturers' concerns that there may be different challenges associated with accommodating the necessary emission control technologies on these smaller engines (even though industry has also gained some limited experience with incorporating fuel-injection on handheld and Class I engines).

The Commission could decide that the recent industry experience in manufacturing small engines with EFI, cited in the staff's technical rationale (Buyer, 2016), while facilitating compliance for some manufacturers of engines and generators, might not shorten the time needed by other manufacturers that have not gained relevant experience in application of EFI technology to their products. Based on recent discussions with generator manufacturers, a longer time frame before compliance is required would allow firms more time to design and build parts in-house, which could be more cost-effective than outsourcing. Lack of relevant recent experience with incorporating EFI in engine manufacturing could be more common for small manufacturers of generators. As noted in the staff's initial regulatory flexibility analysis, a longer period before the rule becomes effective (or before compliance is required for generators with smaller engines) would provide small engine manufacturers more time to develop engines that would meet the requirements of the proposed rule, and in the case of small manufacturers of generators that do not also manufacture their own engines, ''it would provide them with additional time to find a supplier for compliant engines so that their production of generators would not be interrupted [and . . .] for small importers, a later effective date would provide them with additional time to locate a supplier of compliant generators.'' [143]

5. Informational Measures

OMB (2003) notes that informational measures often will be preferable when agencies are considering regulatory action to address a market failure arising from inadequate information. As discussed previously, although labels for generators were improved in 2007, with the introduction of mandatory labels, deaths and injuries from the improper placement of newly purchased generators suggest that at least some consumers poorly understand and process the information contained in the operating instructions and warning labels and consequently, these consumers continue to put themselves and others at risk through the improper placement of generators in enclosed areas. Additionally, a review of injury and market data since improved warning labels have been required finds that there is not sufficient evidence to conclude that the label required in the current labeling standard has reduced the CO fatality risks associated with portable generators. Moreover, findings of other general studies on the effectiveness of labels ''make it seem unlikely that any major reductions in fatalities should be anticipated due to the introduction of these labels.'' [144]

Other informational measures that the Commission could take include increased provision of information through means such as government publications, telephone hotlines, or public interest broadcast announcements. CPSC has previously taken actions to alert consumers to the dangers of CO poisoning by portable generators, and the Commission believes that continued involvement in these activities is warranted. However, evidence of problems in processing information, and continued occurrence of deaths and injuries from improper use of portable generators, indicate that informational measures do not adequately address the risks presented by these products.

6. Taking No Action To Establish a Mandatory Standard

The Commission could take no further regulatory action to establish a mandatory standard on portable

[142] Briefing memorandum for staff's briefing package.

[143] Tab M of the staff's briefing package.

[144] Tab H of the staff's briefing package.

generators. Given that some generator manufacturers have demonstrated that it is technologically feasible to produce generators that emit significantly lower levels of CO, taking no regulatory action to establish a mandatory standard would allow manufacturers to market low CO-emitting generators if they believe that there would be a market for such products. In addition, it would allow fully informed consumers to purchase low CO-emitting generators if they value the reduced risk. However, the Commission does not expect that a significant number of generators with CO emission rates proposed by the standard would be marketed voluntarily, at least in the short run.

H. Conclusions From Preliminary Regulatory Analysis

During 2004 to 2012, there was an average of about 73 portable generator-related deaths and at least 2,800 generator-related nonfatal injuries annually. The societal costs of these injuries, as described above, totaled about $820 million annually. During the same period, there was an average of about 11.1 million portable generators in use, suggesting about 0.66 deaths and at least 25.2 nonfatal CO poisonings per 100,000 portable generators in use. Based on indoor air quality modeling by NIST, and a staff technical evaluation of the predicted health effects for scenarios and housing characteristics found in the CPSC incident data, CPSC estimated that the proposed rule would prevent about one-third of these deaths and injuries.[145]

The preliminary regulatory analysis evaluated the benefits and costs of the proposed rule. It distinguished between four categories of portable generators by engine class and type: (1) Those with handheld engines with displacement of 80 cc or less; (2) generators with Class I engines with engine displacement of less than 225 cc; (3) generators with one-cylinder Class II engines with engine displacement of 225 cc or more; and (4) two-cylinder class II generators with engine displacement of 225 cc or more.

Generators with Class I and one-cylinder Class II engines accounted for about 92.2 percent of portable generators in use over the period 2004 through 2012. Generators with handheld engines (with engine displacement of 80 cc or less) and two-cylinder Class II engines (with displacement of 225 cc or more) accounted for 0.7 percent and 7.1 percent of portable generators in use, respectively, over 2004–2012.

[145] See Tab K of the staff's briefing package.

The preliminary regulatory analysis suggests that the proposed rule could have substantial benefits for most generators. The estimated gross benefits per generator (over its expected product life) ranged from about $215 to $255 for models with hand-held, Class I, and one-cylinder Class II engines. However, gross benefits for the units with two-cylinder Class II engines amounted to only about $4 per unit.

The estimated costs of the proposed rule were generally similar across generator types, ranging from about $110 to $120 per generator for the models with handheld, Class I, and one-cylinder Class II engines, to about $140 for the models with two-cylinder Class I engines. The retail price increases likely to result from these higher costs could reduce portable generator sales by roughly 50,000 units annually, an overall sales reduction of about 3 to 4 percent. The relative impact on handheld generator sales could be greater because of the lower base price of these models.

Given these benefit and cost estimates, net benefits (*i.e.,* benefits minus costs) ranged from about $100 to about $140 per generator for the models with *handheld, Class I, and one-cylinder Class II engines.* However, net benefits were a *negative $135 for the models with two-cylinder Class II engines* (*i.e.,* benefits of $4 per generator minus costs of $139 per generator). Consequently, net benefits for portable generators as a group would be maximized by excluding the models with two-cylinder Class II engines from the rule.

Estimated net benefits can be converted to aggregate annual estimates, given estimates of the annual sales of portable generators. The estimated aggregate net benefits, based on 1 year's sales of the generators with handheld, Class I, and one-cylinder Class II engines amounted to $153 million. Including the models with two-cylinder Class II engines (which account for only about 5 percent of portable generators sold in recent years) under the requirements of the standard would reduce aggregate net benefits to about $145 million annually.

The sensitivity analysis supported the findings of the base analysis. None of the inputs used in the sensitivity analysis altered the main findings that there would be positive net benefits for the generators with handheld, Class I, and one-cylinder Class II engines, but negative net benefits for the generators with two-cylinder Class II engines.

Additionally, we note that benefits of the proposed rule were estimated based on an assumption that consumer behavior would not change in response to knowledge of the reductions in CO emissions from generators. However, a perceived reduction in the risk associated with using the generators in unsafe environments may increase the likelihood that some consumers will use their generators in the house, in the garage, or in outside locations that are near openings to the house—behaviors the CPSC recommends against. Although such a response could offset the expected benefits from the proposed rule, staff anticipates that any impact would be minimal. On the other hand, the benefits estimates were based on 503 of the 659 CO-related deaths during 2004 through 2012. These were the deaths occurring in fixed-residential or similar structures (*e.g.,* detached and attached houses, and fixed mobile homes) that could be modeled by NIST. CPSC staff believes that some unquantified proportion of the remaining 156 deaths that were not modeled by NIST, because they occurred at non-fixed home locations (*e.g.,* temporary structures such as trailers, horse trailers, recreational vehicles, or tents), and some that occurred when portable carbureted generators were operated outdoors, would have been prevented.[146] If so, the benefits estimates would have been somewhat higher than presented in this analysis.

XI. Initial Regulatory Flexibility Analysis

This section provides an analysis of the impact on small businesses of a proposed rule that would establish a mandatory safety standard for portable generators. Whenever an agency is required to publish a proposed rule, section 603 of the Regulatory Flexibility Act (5 U.S.C. 601–612) requires that the agency prepare an initial regulatory flexibility analysis (IRFA) that describes the impact that the rule would have on small businesses and other entities. An IRFA is not required if the head of an agency certifies that the proposed rule will not have a significant economic impact on a substantial number of small entities. 5 U.S.C. 605. The IRFA must contain:

(1) A description of why action by the agency is being considered;

(2) a succinct statement of the objectives of, and legal basis for, the proposed rule;

(3) a description of and, where feasible, an estimate of the number of small entities to which the proposed rule will apply;

[146] Tab K of the staff's briefing package.

(4) a description of the projected reporting, recordkeeping and other compliance requirements of the proposed rule, including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record; and

(5) identification to the extent practicable, of all relevant Federal rules which may duplicate, overlap or conflict with the proposed rule.

An IRFA must also contain a description of any significant alternatives that would accomplish the stated objectives of the applicable statutes and that would minimize any significant economic impact of the proposed rule on small entities. Alternatives could include: (1) Establishment of differing compliance or reporting requirements that take into account the resources available to small businesses; (2) clarification, consolidation, or simplification of compliance and reporting requirements for small entities; (3) use of performance rather than design standards; and (4) an exemption from coverage of the rule, or any part of the rule thereof, for small entities.

A. Reason for Agency Action

The proposed rule would limit the rate of CO emitted by portable generators and is intended to reduce the risk of death or injury resulting from the use of a portable generator in or near an enclosed space. The Directorate for Epidemiology, Division of Hazard Analysis (EPHA) reports that there were 659 deaths involving portable generators from 2004 to 2012, an average of about 73 annually.[147] Furthermore, there was a minimum of 8,703 nonfatal CO poisonings involving portable generators that were treated in hospital emergency departments from 2004 through 2012, or a minimum of about 967 annually (Hanway, 2015); and, as discussed in the preliminary regulatory analysis, there were an additional 16,600 medically attended injuries treated in other settings, or an estimated 1,851 per year. The societal costs of both fatal and nonfatal CO poisoning injuries involving portable generators amounted to about $821 million ($637 million for fatal injuries + $184 million for nonfatal injuries) on an annual basis. The proposed standard is expected to significantly reduce generator-related injuries and deaths and the associated societal costs.

[147] Tab A of the staff's briefing package.

B. Objectives of and Legal Basis for the Rule

The objective of the proposed rule is to reduce deaths and injuries resulting from exposure to CO associated with portable electric generators being used in or near confined spaces. The Commission published an ANPR in December 2006, which initiated this proceeding to evaluate regulatory options and potentially develop a mandatory standard to address the risks of CO poisoning associated with the use of portable generators. The proposed rule is being promulgated under the authority of the Consumer Product Safety Act (CPSA).

C. Small Entities to Which the Rule Will Apply

The proposed rule would apply to small entities that manufacture or import SI portable generators. Based on data collected by Power Systems Research, Trade IQ, and general market research, the Commission has identified more than 70 manufacturers of generators that have at some time supplied portable generators to the U.S. market. However, most of these manufacturers were based in other countries. The Commission has identified 20 domestic manufacturers of gasoline-powered portable generators, of which 13 would be considered small based on the Small Business Administration (SBA) size guidelines for North American Industry Classification System (NAICS) category 335312 (Motor and Generator Manufacturing), which categorizes manufacturers as small if they have fewer than 1,250 employees. Four of the small manufacturers are engaged primarily in the manufacture or supply of larger, commercial, industrial, or backup generators, or other products, such as electric motors, which would not be subject to the draft standard. For the other nine small manufacturers, portable generators could account for a significant portion of the firms' total sales. Of these nine small, domestic manufacturers, six have fewer than 99 employees; one has between 100 and 199 employees; another firm has between 200 and 299 employees; and one has between 300 and 399 employees, based on firm size data from Hoovers, Inc., and interviews with several manufacturers.

In some cases, a small manufacturer may be responsible for designing its own brand of generators but outsource the actual production of the generators to other manufacturers, which are often based in China. Other small manufacturers may assemble using components (including engines) purchased from other suppliers. There may be some small manufacturers that manufacture or fabricate some components of the generators, in addition to assembling them.

Using the same sources of data described above, the Commission identified more than 50 firms that have imported gasoline-powered portable generators. However, in some cases, the firms have not imported generators regularly, and generators appear to account for an insignificant portion of these firm's sales. Of these firms, the Commission believes that 20 may be small importers of gasoline-powered portable generators that could be affected by the proposed rule. Importers were considered to be a small business if they had fewer than 200 employees, based on the SBA guidelines for NAICS category 423610 (Electrical Apparatus and Equipment, Wiring Supplies, and Related Equipment Merchant Wholesalers) or $11.0 million in average annual receipts, based on the SBA guidelines for NAICS category 443141 (Household Appliance Stores). Of the 20 small, potential importers staff identified, all have 50 or fewer employees, based on firm size data from Hoovers, Inc.

D. Compliance, Reporting, and Record Keeping Requirements of Proposed Rule

The proposed rule would establish a performance standard that would limit the rate of CO that could be produced by portable generators that are typically used by consumers for electrical power in emergencies or other circumstances in which the electrical power has been shut off or is not available. The performance standard would be based on the generator's weighted CO emissions rate, and stated in terms of grams/hour (g/hr), depending upon the class [148] of the engine powering the generator. Generators powered by handheld engines and Class I engines would be required to emit CO at a

[148] Because most of the generators that were associated with fatal CO poisoning incidents reported to CPSC were gasoline-fueled, staff has chosen to set the performance standard based on the U.S. Environmental Protection Agency's (EPA) classification of the small SI engine powering the generator and the number of cylinders the engine has. The EPA broadly categorizes small SI engines as either non-handheld or handheld, and within each of those categories, further distinguishes them into different classes, which are based upon engine displacement. Nonhandheld engines are divided into Class I and Class II, with Class I engines having displacement above 80 cc up to 225 cc and Class II having displacement at or above 225 cc but maximum power of 19 kilowatts (kW). Handheld engines, which are divided into Classes III, IV, and V, are all at or below 80 cc. Staff chose to divide non-handheld Class II engines based on whether the engine had a single cylinder or twin cylinders.

weighted rate that is no more than 75 grams per hour (g/hr). Generators powered by Class II engines with a single cylinder would be required to emit CO at a weighted rate that is no more than 150 g/hr. Generators powered by Class II engines with two (or twin) cylinders, which are generally larger than others in the class, and are believed to comprise a very small share of the consumer market, would be required to emit CO at a weighted rate of no more than 300 g/hr.

Section 14 of the CPSA requires that manufacturers, importers, or private labelers of a consumer product subject to a consumer product safety rule to certify, based on a test of each product or a reasonable testing program that the product complies with all rules, bans or standards applicable to the product. The proposed rule details the test procedure that the Commission would use to determine compliance with the standard, but also provides that any test procedure may be used that will accurately determine the emission level of the portable generator. However, for certification purposes, manufacturers must certify that the product conforms to the standard, based on either a test of each product, or any reasonable alternative method to demonstrate compliance with the requirements of the standard. For products that manufacturers certify, manufacturers would issue a general certificate of conformity (GCC).

The requirements for GCCs are in Section 14 of the CPSA. Among other requirements, each certificate must identify the manufacturer or private labeler issuing the certificate and any third party conformity assessment body, on whose testing the certificate depends, the place of manufacture, the date and place where the product was tested, each party's name, full mailing address, telephone number, and contact information for the individual responsible for maintaining records of test results. The certificates must be in English. The certificates must be furnished to each distributor or retailer of the product and to the CPSC, if requested.

1. Costs of Proposed Rule That Would Be Incurred by Small Manufacturers

The most likely method for manufacturers of portable generators to comply with the proposed CO emissions requirement is converting to the use of closed-loop electronic fuel-injection (EFI) systems instead of conventional carburetors, to control the delivery of gasoline to the pistons of generator engines. Manufacturers also are likely to use catalytic converters in the mufflers of the generator engines. As discussed in the preliminary regulatory analysis in Section X, the cost to manufacturers for complying with the proposed rule is expected to be, on average, about $114 per unit for generators with handheld engines (1.1% of unit sales between 2010 and 2014), $113 per unit for generators with Class I engines (57.8% of unit sales between 2010 and 2014); $110 for those with single cylinder Class II engines (36.4% of unit sales between 2010 and 2014); and $138 for those with twin cylinder Class II engines (4.7% of unit sales between 2010 and 2014).

These estimates include the variable costs related to EFI, including an oxygen sensor for a closed-loop system, a battery and alternator or regulator; and 3-way catalysts. The estimates also include the fixed costs associated with the research and development required to redesign the generators, tooling costs, and the costs associated with testing and certification that the redesigned engines comply with the EPA requirements for exhaust constituents they regulate, $HC+NO_X$ and CO emissions.[149]

Manufacturers likely would incur some additional costs to certify that their portable generators meet the requirements of the proposed rule, as required by Section 14 of the CPSA. The certification must be based on a test of each product or a reasonable testing program. Manufacturers may use any testing method that they believe is reasonable and are not required to use the same test method that would be used by CPSC to test for compliance. Based on information from a testing laboratory, the cost of the testing might be more than $6,000 per generator model, although it may be possible to use the results from other tests that manufacturers already may be conducting, such as testing to ensure that the engines comply with EPA requirements, per 40 CFR part 1054, for $HC+NO_X$ and CO emissions to certify that the generator meets the requirements of the proposed rule. Manufacturers and importers also may rely upon testing completed by other parties, such as their foreign suppliers, in the case of importers, or the engine suppliers in the case of manufacturers, if those tests provide sufficient information for the manufacturers or importers to certify that the generators comply with the proposed rule.

The Commission welcomes comments from the public regarding the cost or other impacts of the certification requirements under Section 14 of the CPSA and whether it would be feasible to use the results of tests conducted for certifying compliance with EPA requirements to certify compliance with the proposed rule.

2. Impacts on Small Businesses

Manufacturers

To comply with the proposed rule, small manufacturers would incur the costs described above to redesign and manufacture generators that comply with the CO emissions requirements and to certify that they comply. However, to the extent that the volume of generators produced by small manufacturers is lower than that of the larger manufacturers, the costs incurred by smaller manufacturers may be higher than the average costs reported above. One reason to expect that costs for lower-volume manufacturers could be higher than average is that some of the costs are fixed. For example, research and development costs were estimated to be about $203,000, on average, for Class II engines and about $316,000 for Class I engines. On a per-unit basis, the preliminary regulatory analysis estimated that these costs would average about $4 for Class I engines and $3 for Class II engines, but for manufacturers with a production volume only one-half the average production volume, the per-unit costs would be twice the average.

For lower-volume producers, the per-unit costs of the components necessary to modify their engines might also be higher than those for higher-volume producers. As discussed in the preliminary regulatory analysis, generators that meet the requirements of the proposed rule would probably use closed-loop electronic fuel-injection instead of conventional carburetors. Therefore, manufacturers would incur the costs of adding components associated with EFI to the generator, including injectors, pressure regulators, sensors, fuel pumps, and batteries. Based on information obtained from a generator manufacturer, the cost of these components might be as much as 35 percent higher for a manufacturer that purchased only a few thousand units at a time, as opposed to more than 100,000 units.

[149] The modifications to small SI engines to comply with the CO emission requirements would likely require engine manufacturers to seek certifications (as new engine families) under EPA requirements for $HC+NO_X$ and CO, with the attendant costs for fees and testing, which could be passed on to generator manufacturers that purchase the engines to power their products. Some of the larger manufacturers of portable generators are vertically-integrated firms that also manufacture the engines that power their products. These testing and certification requirements are to meet EPA requirements and are in addition to the testing and certification requirements of Section 14 of the CPSA.

While the cost for small, low-volume manufacturers that manufacture their own engines might be higher than for high-volume manufacturers, small portable generator manufacturers often do not manufacture the engines used in their generators, but obtain them from engine manufacturers such as Honda, Briggs and Stratton, and Kohler, as well as several engine manufacturers based in China. These engine manufacturers often supply the same engines to other generator or engine-driven tool manufacturers. Because these engine manufacturers would be expected to have higher production volumes and can spread the fixed research and development and tooling costs over a higher volume of production, the potential disproportionate impact on lower-volume generator producers might be mitigated to some extent.

As discussed in the preliminary regulatory analysis, the retail prices CPSC observed for portable generators from manufacturers and importers of all sizes ranged from a low of $133 to $4,399, depending upon the characteristics of the generator. On a per-unit basis, the proposed rule is expected to increase the costs of generators by an average of $110 to $140. Generally, impacts that exceed 1 percent of a firm's revenue are considered to be potentially significant. Because the estimated average cost per generator would be between about 3 percent and 80 percent of the retail prices (or average revenue) of generators, the proposed rule could have a significant impact on manufacturers and importers that receive a significant portion of their revenue from the sale of portable generators.

Based on a conversation with a small manufacturer, CPSC staff believes that the proposed rule may have a disproportionate impact on generator manufacturers that compete largely on the basis of price, rather than brand name or reputation. Currently, CPSC cannot identify how many of the nine domestic small manufacturers of engines compete on the basis of price. One reason for the disproportionate impact is that consumers of the lower priced generators are probably more price sensitive than consumers of the brand name generators and may be more likely to reduce or delay their purchases of generators in response to the cost increases that would be expected to result from the proposed rule. A second reason that manufacturers that compete largely on the basis of price could be disproportionately impacted is that brand name generator manufacturers might have more options for absorbing the cost increases that result from the proposed rule. For example a high-end generator manufacturer might be able to substitute a less expensive, but still adequate engine for a name brand engine that they currently might be using. On the other hand, manufacturers that have been competing primarily on the basis of price are more likely to have already made such substitutions and will have fewer options for absorbing any cost increases. As a result, the price differential between generators aimed at the low-end or price-conscious market segments and the name brand generators will be reduced, which could affect the ability of the manufacturers of generators aimed at the price conscious market to compete with the name-brand manufacturers.

Importers

For many small importers, the impact of the proposed rule would be expected to be similar to the impact on small manufacturers. One would expect that the foreign suppliers would pass much of the costs of redesigning and manufacturing portable generators that comply with the proposed rule to their domestic distributors. Therefore, the cost increases experienced by small importers would be similar to those experienced by small manufacturers. As with small manufacturers, the impact of the proposed rule might be greater for those importers that primarily compete on the basis of price. Currently, CPSC cannot identify how many of the 20 domestic, small importers of engines compete on the basis of price.

In some cases, the foreign suppliers might opt to withdraw from the U.S. market, rather than incur the costs of redesigning their generators to comply with the proposed rule. If this occurs, the domestic importers would have to find other suppliers of portable generators or exit the portable generator market. Exiting the portable generator market could be considered a significant impact, if portable generators accounted for a significant percentage of the firm's revenue.

Small importers will be responsible for issuing a GCC certifying that their portable generators comply with the proposed rule should it become final. However, importers may rely upon testing performed and GCCs issued by their suppliers in complying with this requirement.

E. Federal Rules That May Duplicate, Overlap, or Conflict With the Proposed Rule

The Commission has not identified any federal rules that duplicate or conflict with the proposed rule. The EPA promulgated a standard in 2008 for small spark-ignited engines that set a maximum rate for CO emissions. However, the maximum level set by the EPA is higher than the proposed CPSC standard for portable generators.

F. Alternatives Considered To Reduce the Burden on Small Entities

Under section 603(c) of the Regulatory Flexibility Act, an initial regulatory flexibility analysis should ''contain a description of any significant alternatives to the proposed rule which accomplish the stated objectives of the applicable statutes and which minimize any significant impact of the proposed rule on small entities.'' CPSC examined several alternatives to the proposed rule that could reduce the impact on small entities. These include: (1) Less stringent CO emission rates; (2) limit coverage to one-cylinder engines; (3) an option for reducing consumer exposure to CO by using an automatic shutoff; (4) establishing alternative compliance dates; (5) informational measures; or (6) taking no action. These alternatives are discussed in more detail in Section X.G.

G. Summary and Request for Comments Regarding Potential Impact on Small Business

The Commission has identified about nine small generator manufacturers and about 20 small generator importers that would be impacted by the proposed rule.

The most likely means of complying with the proposed rule would be to use closed-loop electronic fuel-injection (EFI) systems, instead of conventional carburetors, to control the delivery of gasoline to the pistons of generator engines and to use catalytic converters in the mufflers of the generator engines to be able to meet the EPA's $HC+NO_X$ emission standards. The Commission estimates that, on average, the requirements will increase the costs of generator manufacturers by about $110 and $140, depending upon engine type. The costs might be higher than average for lower-volume manufacturers.

Manufacturers and suppliers that serve the low-end of the market and compete mostly on the basis of price might be more severely impacted by the proposed rule because their customers may be more price sensitive; and compared with larger manufacturers, they may not have the same options of reducing other costs to mitigate the impact of the proposed rule on the price of generators. Suppliers of name-brand generators or ones that compete on basis other than price might be able to make other adjustments, such as using less expensive engines to mitigate the impact of the proposed rule on the price of their generators. CPSC currently cannot identify how many of the nine domestic, small manufacturers or the 20 domestic, small importers of engines compete on the basis of price.

Generator manufacturers and importers will be responsible for certifying that their products comply with the requirements of the proposed rule. Testing and certification costs can have a disproportionate impact on small manufacturers, depending upon the cost of the tests and volume of production, relative to larger manufacturers. However, some of these testing costs might be mitigated, if manufacturers could use the results of testing already being conducted (such as, for example, testing to certify compliance with EPA requirements), to offset some of the testing costs required for certification with the proposed rule.

The Commission invites comments on this IRFA and the potential impact of the proposed rule on small entities, especially small businesses. Small businesses that believe they will be affected by the proposed rule are especially encouraged to submit comments. The comments should be specific and describe the potential impact, magnitude, and alternatives that could reduce the impact of the proposed rule on small businesses.

In particular, the Commission seeks comment on:

- The types and magnitude of manufacturing costs that might disproportionately impact small businesses or that were not considered in this analysis;
- the costs of the testing and certification requirements of the proposed rule, including whether EPA testing can be used to meet the certification requirements for the proposed rule;
- whether other factors not considered in this analysis could be significant, such as EPA's Averaging, Banking and Trading (ABT) program that could allow manufacturers of engine families that do have low CO emissions to meet the proposed rule and that also have very low $HC+NO_X$ emissions to ''buy credits'' in the ABT program, thus allowing their other engine families to exceed $HC+NO_X$ limits;
- differential impacts of the proposed rule on small manufacturers or suppliers that compete in different segments of the portable generator market; and finally,
- CPSC would be interested in any comments that provide alternatives that would minimize the impact on small businesses but would still reduce the risk of CO poisoning associated with generators.

XII. Environmental Considerations

The Commission's regulations address whether CPSC is required to prepare an environmental assessment (EA) or an environmental impact statement (EIS). 16 CFR 1021.5. Those regulations state CPSC's actions that ordinarily have ''little or no potential for affecting the human environment,'' and therefore, are categorically excluded from the need to prepare an EA or EIS. Among those actions are rules, such as the portable generator NPR, which provide performance standards for products. *Id.* 1021.5(c)(1).

XIII. Executive Order 12988 (Preemption)

In accordance with Executive Order 12988 (February 5, 1996), the CPSC states the preemptive effect of the proposed rule, as follows:

The regulation for portable generators is proposed under authority of the CPSA. 15 U.S.C. 2051–2089. Section 26 of the CPSA provides: ''whenever a consumer product safety standard under this Act is in effect and applies to a risk of injury associated with a consumer product, no State or political subdivision of a State shall have any authority either to establish or to continue in effect any provision of a safety standard or regulation which prescribes any requirements as to the performance, composition, contents, design, finish, construction, packaging or labeling of such product which are designed to deal with the same risk of injury associated with such consumer product, unless such requirements are identical to the requirements of the Federal Standard''. 15 U.S.C. 2075(a). Upon application to the Commission, a state or local standard may be excepted from this preemptive effect if the state or local standard: (1) Provides a higher degree of protection from the risk of injury or illness than the CPSA standard, and (2) does not unduly burden interstate commerce. In addition, the federal government, or a state or local government, may establish or continue in effect a non-identical requirement for its own use that is designed to protect against the same risk of injury as the CPSC standard if the federal, state, or local requirement provides a higher degree of protection than the CPSA requirement. 15 U.S.C. 2075(b).

Thus, the portable generator requirements proposed in this **Federal Register** would (if finalized) preempt non-identical state or local requirements for portable generators designed to protect against the same risk of injury and prescribing requirements regarding the performance, composition, contents, design, finish, construction, packaging or labeling of portable generators.

XIV. Certification

Section 14(a) of the CPSA requires that products subject to a consumer product safety rule under the CPSA, or to a similar rule, ban, standard or regulation under any other act enforced by the Commission, must be certified as complying with all applicable CPSC-enforced requirements. 15 U.S.C. 2063(a). A final rule on portable generators would subject portable generators to this certification requirement.

XV. Effective Date

The CPSA requires that consumer product safety rules take effect not later than 180 days from their promulgation unless the Commission finds there is good cause for a later date. 15 U.S.C. 2058(g)(1). The Commission proposes that the rule would take effect 1 year from the date of publication of the final rule for generators powered by Class II engines and three years from the date of publication of the final rule for generators powered by handheld and Class I engines.

Because of the experience gained by engine manufacturers in recent years in designing and building EFI small SI engines, the Commission believes one year from the date of publication of the final rule would provide an appropriate lead-time for generators powered by one and two cylinder Class II engines. The Commission is proposing an effective date of three years from the date of publication of the final rule for generators powered by handheld and Class I engines. This longer period to become compliant addresses manufacturers' concerns that there may be different challenges associated with accommodating the necessary emission control technologies on these smaller engines. In addition, later compliance dates could potentially reduce the impact on manufacturers of generators, including small manufacturers, by providing them with more time to develop engines that would meet the requirements of the proposed rule, or, in the case of small manufacturers that do not manufacture the engines used in their generators, by providing them with additional time to find a supplier for compliant engines so that their production of generators would not be interrupted.

XVI. Proposed Findings

The CPSA requires the Commission to make certain findings when issuing a consumer product safety standard. Specifically, the CPSA requires that the Commission consider and make findings about the degree and nature of the risk of injury; the number of consumer products subject to the rule; the need of the public for the product and the probable effect on utility, cost, and availability of the product; and other means to achieve the objective of the rule, while minimizing the impact on competition, manufacturing, and commercial practices. The CPSA also requires that the Commission find that the rule is reasonably necessary to eliminate or reduce an unreasonable risk of injury associated with the product and issuing the rule must be in the public interest. 15 U.S.C. 2058(f)(3).

In addition, the Commission must find that: (1) If an applicable voluntary standard has been adopted and implemented, that compliance with the voluntary standard is not likely to reduce adequately the risk of injury, or compliance with the voluntary standard is not likely to be substantial; (2) that benefits expected from the regulation bear a reasonable relationship to its costs; and (3) that the regulation imposes the least burdensome requirement that would prevent or adequately reduce the risk of injury. *Id.* These findings are discussed below.

Degree and nature of the risk of injury.

Carbon monoxide is a colorless, odorless, poisonous gas formed during incomplete combustion of fossil fuels, such as the fuels used in engines that power portable generators. Mild CO poisoning symptoms include headaches, lightheadedness, nausea, and fatigue. More severe CO poisoning can result in progressively worsening symptoms of vomiting, confusion, loss of consciousness, coma, and ultimately, death. The high CO emission rate of current generators can result in situations in which the COHb levels of exposed individuals rise suddenly and steeply, causing them to experience rapid onset of confusion, loss of muscular coordination, and loss of consciousness.

As of May 21, 2015, CPSC databases contained reports of at least 751 generator-related consumer CO poisoning deaths resulting from 562 incidents, which occurred from 2004 through 2014. Due to incident reporting delays, statistics for the two most recent years, 2013 and 2014, are incomplete, because data collection is still ongoing, and the death count most likely will increase in future reports.

Based on NEISS, the Commission estimates that for the 9-year period of 2004 through 2012, there were 8,703 CO injuries seen in emergency departments (EDs) associated with portable generators. The Commission considers this number to represent a lower bound on the true number of generator-related CO injuries treated in EDs from 2004–2012. According to Injury Cost Model (ICM) estimates, there were an additional 16,660 medically-attended CO injuries involving generators during 2004–2012.

Number of consumer products subject to the rule.

For the U.S. market for the years 2010 through 2014, about 6.9 million gasoline-powered portable generators were shipped for consumer use, or an average of about 1.4 million units per year. Shipments of nearly 1.6 million units in 2013 made it the peak year for estimated sales during this period. Consumer demand for portable generators from year-to-year fluctuates with major power outages, such as those caused by tropical or winter storms. Portable generators purchased by consumers and in household use generally range from under 1 kW of rated power up to perhaps 15 kW of rated power. In the last 10 to 15 years, the U.S. market has shifted towards smaller, less powerful units.

The need of the public for portable generators and the effects of the rule on their utility, cost, and availability.

Portable generators that are the subject of the proposed standard commonly are purchased by consumers to provide electrical power during emergencies (such as during outages caused by storms), during other times when electrical power to the home has been shut off, when power is needed at locations around the home without access to electricity, and for recreational activities (such as during camping or recreational vehicle trips).

The proposed rule is based on technically feasible CO emission rates, so that the function of portable generators is unlikely to be adversely affected by the rule. Moreover, there may be a positive change in utility in terms of fuel efficiency, greater ease of starting, product quality, and safety of portable generators. There may be a negative effect on the utility of portable generators, however, to the extent consumers are unable to purchase generators due to increased retail prices.

In terms of retail price information, the Commission's review found that generators with handheld engines ranged in price from $133 to $799, with an average price of about $324. Generators with non-handheld Class I engines had a wide price range, from $190 to over $2,000, with an average price of $534. Generators with one-cylinder Class II engines ranged in price from $329 to $3,999, with an average price of $1,009. Generators with two-cylinder Class II engines ranged in price from $1,600 to $4,999, and the average price of these units was $2,550.

Aggregate estimated compliance costs to manufacturers of portable generators average approximately $113 per unit for engine and muffler modifications necessary to comply with the CO emission requirements of the proposed standard. The net estimated manufacturing costs per unit to comply with the proposed standard is $114 for handheld engines, $113 for Class I engines, $110 for Class II, one cylinder engines, and $138 for Class II, two cylinder engines.

The expected product modifications to produce complying generators (EFI & catalysts) are available to manufacturers, and the Commission does not have any indication that firms would exit the market because of the rule. Therefore, the availability of portable generators would not likely be affected by the rule.

Other means to achieve the objective of the rule, while minimizing the impact on competition and manufacturing.

The Commission considered alternatives to achieving the objective of the rule of reducing unreasonable risks of injury and death associated with portable generators. For example, the Commission considered less stringent CO emission rates for portable generators; however, cost savings from less-stringent CO emission requirements likely would be less than expected reductions in the benefits, so that the net benefits of the rule probably would decrease under this regulatory alternative. The Commission also considered including an option for reducing CO emissions through use of automatic shutoff systems, which could potentially reduce the impact of the proposed rule by providing an additional option for complying with the proposed rule; however, because of unresolved issues concerning an automatic shutoff, the Commission does not believe that a regulatory alternative based on automatic shutoff technology instead of reduced emissions is feasible for hazard reduction at this time.

Unreasonable risk.

As of May 21, 2015, CPSC databases contained reports of at least 751 generator-related consumer CO poisoning deaths resulting from 562 incidents, which occurred from 2004 through 2014. Due to incident reporting delays, statistics for the two most recent years, 2013 and 2014, are incomplete, because data collection is still ongoing, and the death count most likely will increase in future reports.

Based on NEISS, the Commission estimates that for the 9-year period of 2004 through 2012, there were 8,703 CO injuries seen in emergency departments (EDs) associated with portable generators. The Commission considers this number to represent a lower bound on the true number of generator-related CO injuries treated in EDs from 2004–2012. According to Injury Cost Model (ICM) estimates, there were an additional 16,660 medically-attended CO injuries involving generators during 2004–2012.

The Commission estimates that the rule would result in aggregate net benefits of about $145 million annually. On a per-unit basis, the Commission estimates the present value of the expected benefits per unit for all units to be $227; the expected costs to manufacturers plus the lost consumer surplus per unit to be $116; and the net benefits per unit to be $110. The Commission concludes preliminarily portable generators pose an unreasonable risk of injury and finds that the proposed rule is reasonably necessary to reduce that unreasonable risk of injury.

Public interest.

This proposed rule is intended to address an unreasonable risk of injury and death posed by portable generators. The Commission believes that adherence to the requirements of the proposed rule will reduce portable generator deaths and injuries in the future; thus, the rule is in the public interest.

Voluntary standards.

The Commission is aware of two U.S. voluntary standards that are applicable to portable generators, UL 2201—*Safety Standard for Portable Generator Assemblies,* and ANSI/PGMA G300–2015—*Safety and Performance of Portable Generators.* These standards include the same requirements set forth in the mandatory CPSC portable generator label but do not otherwise address the risks related to CO poisoning. The Commission does not believe the standards are adequate because they fail to address the risk of CO hazard beyond the CPSC mandatory labeling requirement. The Commission is unaware of any portable generator that has been certified to either of the standards, and as such it is unlikely whether there would be substantial compliance with it if CO emissions requirements were incorporated.

Relationship of benefits to costs.

The aggregate annual benefits and costs of the rule are estimated to be about $298 million and $153 million, respectively. Aggregate net benefits from the rule, therefore, are estimated to be about $145 million annually. On a per unit basis, the Commission estimates the present value of the expected benefits per unit for all units to be $227. The Commission estimates the expected costs to manufacturers plus the lost consumer surplus per unit to be $116. Based on this analysis, the Commission preliminarily finds that the benefits expected from the rule bear a reasonable relationship to the anticipated costs of the rule.

Least burdensome requirement that would adequately reduce the risk of injury.

The Commission considered less-burdensome alternatives to the proposed rule on portable generators, but preliminarily concluded that none of these alternatives would adequately reduce the risk of injury.

(1) The Commission considered not issuing a mandatory rule, but instead relying upon voluntary standards. As discussed previously, the Commission does not believe that either voluntary standard adequately addresses the CO risk of injury and death associated with portable generators. Furthermore, in the absence of any indication that a portable generator has been certified to either standard, the Commission cannot determine that there would be substantial compliance by industry.

(2) The Commission considered excluding portable generators with two cylinder Class II engines from the scope of the rule. The Commission estimates that net benefits of the proposed rule range from about $100 to about $140 per generator for the models with handheld, Class I and one-cylinder Class II engines. However, the Commission estimates net benefits of negative $135 for the models with two-cylinder Class II engines. Consequently, excluding portable generators with two cylinder Class II engines would result in a less burdensome alternative. However, it is possible that exclusion of generators with two-cylinder Class II engines from the scope of the rule could create an economic incentive for manufacturers of generators with larger one-cylinder engines to either switch to two-cylinder engines for those models, or if they already have two-cylinder models in their product lines, they could be more likely to drop larger one-cylinder models from their product lines. Because the Commission lacks more specific information on the generators with Class II twin cylinder engines, the Commission is proposing this rule with the broader scope of including these generators. The Commission welcomes comments on inclusion of portable generators with Class II twin cylinder engines, or Class 2 twin cylinder generators, in the scope of the rule.

(3) The Commission considered higher allowable CO emission rates, which might result in costs savings from lower costs associated with catalysts (if they would not be required, or if less-costly materials could suffice), less-extensive engine modifications (other than EFI-related costs) and less-extensive generator housing modifications (if housing enlargement and other retooling would be minimized). However, based on Commission estimates, it seems likely that cost savings from less-stringent CO emission requirements would be less than expected reductions in benefits. Therefore, the Commission is not proposing this alternative.

XVII. Ex Ante Retrospective Review

As set forth in the Commission's Plan for Retrospective Review of Existing Rules (Retrospective Review Plan) (*http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Rulemaking/DraftrulereviewplanSeptember2015Final.pdf*) and consistent with the Regulatory Flexibility Act, as applicable, the Commission has established certain methods and processes for identifying and reconsidering certain rules that warrant repeal or modification, including rules that would benefit from strengthening, complementing, or modernizing. Consistent with the Retrospective Review Plan's methods and procedures, which permit the Commission to include retrospective review provisions in new rulemakings, the Commission is requesting comments on whether to develop ex ante criteria for the retrospective review of this proposed rule.

XVIII. Request for Comments

We invite all interested persons to submit comments on any aspect of the proposed rule. More specifically, the Commission seeks comments on the following:

• The cost or other impacts of the certification requirements under Section 14 of the CPSA and whether it would be feasible to use the results of tests conducted for certifying compliance with EPA requirements to certify compliance with the proposed rule;

• The product manufacture or import limits and the base period in the proposed anti-stockpiling provision;

• Prospective use (*e.g.,* costs, applicability and challenges) of battery-less EFI for portable generators;

• Costs of new designs and tooling that may be required for generator frames and housings to accommodate additional components, such as batteries for generators with handheld or Class I engines, and to address reported concerns with heat dissipation.

• Information on potential challenges in accommodating new features in handheld and Class I engines to comply with the proposed rule, as well as on components and technologies that might be available to meet these challenges and moderate the impacts of the proposed rule on handheld and Class I engines.

• Costs per unit element for testing and certification, including what additional costs per unit element might be if the Commission required specific testing requirements;

• Costs firms experience with testing and certification of engines for EPA emissions testing;

• Advantages and disadvantages of setting performance requirements at 17 percent oxygen instead of normal oxygen as well as comments on the technically feasible CO emission rates for generators operating at 17 percent oxygen, for each of the generator categories.

• Based on estimates made for EPA, estimated variable costs for a pressurized oil system would be about $19 for small spark-ignition engines that that now lack this feature. In the view of the Directorate for Engineering Sciences, pressurized lubrication systems would not be necessary to comply with the draft standard. We welcome comments on this issue.

• Whether to exclude portable generators with two-cylinder Class II engines from the final rule, and if two-cylinder Class II engines were to be excluded, whether a limit on displacement should be included to avoid developing a market for small two-cylinder engines for portable generators that would be exempt from the rule;

• Information on the benefits and costs that would be associated with different CO emission rates;

• Information and data about the expected range of manufacturing variability for CO emissions from EFI equipped small spark ignited engines, including data on emissions variability from production target values and expected manufacturing tolerances.

• Information about the benefits and costs associated with altering the performance requirements for CO emissions such that an alternate performance requirement could be based on limits on those emissions when the generator is operating in air with reduced oxygen content of 17 percent oxygen (or a different reduced level) rather than normal atmospheric oxygen (approximately 20.9 percent), as proposed; if so, what that performance requirement should be and how should CPSC should test to verify compliance.

• Test methods staff use for determining CO emissions from generators in normal atmospheric oxygen levels (approximately 20.9 percent) and at reduced oxygen levels (as described in staff's briefing package), as well information on benefits and costs that could be associated with requiring those specific methods for evaluation and the benefits and costs of not requiring a specific test method.

• The appropriateness of compliance dates that are one year from the date of publication of the final rule for portable generators with Class II engines, or class 2 generators, and three years from the date of publication of the final rule for generators with handheld and Class I engines, or handheld generators and class 1 generators.

• Whether the Commission should instead adopt a compliance date that is 18 months from the date of publication of the final rule for generators with handheld and Class I engines, or handheld generators and class 1 generators.

• Possible alternative technologies that would address the carbon monoxide hazard associated with portable generators other than or in addition to reduced carbon monoxide generation, such as, but not limited to, viable shut-off technology. For any proposed alternate technology, please provide a description of how its performance would be characterized, any challenges to implementation, data showing the viability of the technology in this application and any other information that would help evaluate the efficacy and cost of the alternate approach.

• The feasibility of continuing to lower in the future the CO rate requirements for portable generators as technology advances and whether the Commission can make related findings that CO emission rates lower than those set forth in the proposed rule will further reduce the risk of death and injury associated with this hazard. Provide information on a timetable or other automatic mechanism that would trigger a review of the emission rates for purposes of evaluating the feasibility of establishing lower rates as well as any metrics that would be used to evaluate the state of the technology for the purpose of lowering the CO rates in the rule.

• Potential increase in fuel economy resulting from this proposed performance standard and quantification of costs or benefits associated with such increase.

• Potential impact of this proposed performance standard on the market for handheld generators and costs or benefits associated with such impact.

• Potential impact noise emissions associated with this proposed performance standard and any advantages or disadvantages of such impact.

• The need for retrospective review of this proposed rule, including the need for development of ex ante criteria, pursuant to the selection criteria set forth in the Commission's Retrospective Review Plan. Examples of potential criteria for any future retrospective review of this proposed rule include, but are not limited to: The appropriate data points necessary to evaluate such measures, the appropriate interval for such retrospective review, and the appropriate goals to define success in each measure.

• Additional information on portable generator sales and use.

Comments should be submitted in accordance with the instructions in the **ADDRESSES** section at the beginning of this document.

XIX. Conclusion

For the reasons stated in this preamble, the Commission proposes requirements for portable generators to address an unreasonable risk of injury associated with portable generators.

List of Subjects in 16 CFR Part 1241

Consumer protection, Imports, Information, Safety.

For the reasons discussed in the preamble, the Commission proposes to amend Title 16 of the Code of Federal Regulations as follows:

■ 1. Add part 1241 to read as follows:

PART 1241—SAFETY STANDARD FOR PORTABLE GENERATORS

Sec.

Authority: 15 U.S.C. 2056, 2058 and 2076.

§ 1241.1 Scope, purpose and compliance dates.

(a) This part 1241, a consumer product safety standard, establishes requirements for portable generators, as defined in § 1241.2(b). The standard includes requirements for carbon monoxide emission rates for categories of portable generators. These requirements are intended to reduce an unreasonable risk of injury and death associated with portable generators.

(b) For purposes of this rule, portable generators include single phase; 300 V or lower; 60 hertz; portable generators driven by small handheld and non-handheld (as defined by the Environmental Protection Agency) spark-ignited utility engines intended for multiple use which are provided only with receptacle outlets for the AC output circuits and intended to be moved, though not necessarily with wheels. For purposes of this rule, portable generators do not include:

(1) Permanently installed generators;

(2) 50 hertz generators;

(3) Marine generators;

(4) Trailer mounted generators;

(5) Generators installed in recreational vehicles;

(6) Generators intended to be pulled by vehicles;

(7) Generators that are part of welding machines;

(8) Generators powered by compression-ignition engines fueled by diesel.

(c) Class 2 single cylinder and two cylinder generators, as defined in § 1241.2(c) and (d) manufactured or imported on or after [date that is 365 days after publication of a final rule] shall comply with the requirements stated in § 1241.3(b)(2) and (3). Handheld generators and Class 1 generators, as defined in § 1241.2(a) and (b), manufactured or imported on or after [date that is 3 years after publication of a final rule], shall comply with the requirements stated in § 1241.3(b)(1).

§ 1241.2 Definitions.

In addition to the definitions in section 3 of the Consumer Product Safety Act (15 U.S.C. 2051), the following definitions apply for purposes of this part 1241.

(a) *Handheld generator* means a generator powered by a spark ignited (SI) engine with displacement of 80 cc or less.

(b) *Class 1 generator* means a generator powered by an SI engine with displacement greater than 80 cc but less than 225 cc.

(c) *Class 2 single cylinder generator* means a generator powered by an SI engine with one cylinder having displacement of 225 cc or greater, up to a maximum engine power of 25 kW.

(d) *Class 2 two cylinder generator* means a generator powered by an SI engine with two cylinders having a total displacement of 225 cc or greater, up to a maximum engine power of 25 kW.

§ 1241.3 Requirements.

(a) When tested in accordance with the test procedures stated in § 1241.4 (or similar test procedures), all portable generators covered by this standard shall meet the requirements stated in paragraph (b) of this section.

(b) Emission rate requirements.

(1) Handheld generators and Class 1 generators must not exceed a weighted CO emission rate of 75 grams per hour (g/hr).

(2) Class 2 single cylinder generators must not exceed a weighted CO emission rate of 150 g/hr.

(3) Class 2 two cylinder generators must not exceed a weighted CO emission rate of 300 g/hr.

§ 1241.4 Test procedures.

(a) Any test procedure that will accurately determine the carbon monoxide emission rate of the portable generator may be used. CPSC uses the test procedure stated in this section to determine compliance with the standard.

(b) *Definitions.*

(1) *Load bank and power meter* means an AC electric resistor load bank used to simulate steady electric loads on the generator. The load bank shall be capable of adjustment to within 5 percent of each required load condition. A power meter is used to measure the actual electrical load delivered by the generator with an accuracy of ±5 percent.

(2) *Fuel and lubricants* means fuel and lubricants that meet manufacturer's specifications for the generator being tested.

(3) Emission measurement system means the constant volume sampling (CVS) emission measurement system described in 40 CFR parts 1054 and 1065.

(4) Maximum *generator load* means the maximum output power capability of the generator assembly as determined by the maximum generator load determination procedures. The maximum generator load is used to establish the 6-mode load profile.

(c) Determining maximum generator load.

(1) *Power saturation method for conventional (non-inverter) generator assemblies.*

(i) Ensure test facility is at ambient conditions 15–30 °C (60–85 °F) and approximately 20.9 percent oxygen.

(ii) Apply a load greater than 60 percent of the manufacturer's rated continuous power for a minimum of 20 minutes to warm the generator to operating temperature.

(iii) Monitoring voltage and frequency, increase the load applied to the generator to the maximum observed power output without causing the voltage or frequency to deviate from the following tolerances:

(A) Voltage Tolerance: ±10 percent of the nameplate rated voltage.

(B) Frequency Tolerance: ±5 percent of the nameplate rated frequency.

(iv) Maintain the maximum observed power output until the operating temperature of the engine stabilizes. The generator is at stable operating temperature when the oil temperature varies by less than 2 °C (4 °F) over three consecutive readings taken 15 minutes apart. For the purpose of determining maximum generator load, if an overload protection device is present, it shall not activate for a period of 45 minutes from the initial operating temperature stability reading. The load may need to be adjusted to maintain the maximum observed power output while the generator temperatures are stabilizing. Record voltage, frequency, amperage, power, and oil and ambient air temperature.

(v) The maximum generator load is the power supplied by the generator assembly that satisfies the tolerances in paragraph (c)(1)(iii) of this section when the generator is at stable operating temperature as defined in paragraph (c)(iv) of this section. Record the maximum generator load.

(2) *Power saturation method for inverter generator assemblies.*

(i) Ensure test facility is at ambient conditions 15–30 °C (60–85 °F) and approximately 20.9 percent oxygen.

(ii) Apply a load greater than 60 percent of the manufacturer's rated continuous power for a minimum of 20 minutes to warm the generator to operating temperature.

(iii) Increase the load applied to the generator to the maximum observed power output.

(iv) Maintain the maximum observed power output until the operating temperature of the engine stabilizes. The generator is at stable operating temperature when the oil temperature varies by less than 2 °C (4 °F) over three consecutive readings taken 15 minutes apart. For the purpose of determining maximum generator load, if an overload protection device is present, it shall not activate for a period of 45 minutes from the initial operating temperature stability reading. The load may need to be adjusted to maintain the maximum observed power output while the generator temperatures are stabilizing. Record voltage, frequency, amperage, power, and oil and ambient air temperature.

(v) Maximum generator load is the maximum observed power output that satisfies the criteria defined in paragraph (c)(2)(iv) of this section. Record the maximum generator load.

(d) *Test method to determine the modal CO emission rates of a portable generator.* To determine the weighted CO emission rate of a portable generator assembly, determine the modal CO emission rates at six discrete generator loads based on maximum generator load using a CVS emissions tunnel described in 40 CFR parts 1054 and 1065, and calculate the weighted CO emission rate. All tests shall be performed under typical operating conditions at an ambient air temperature of 15–30 °C (60–85 °F) and approximately 20.9 percent oxygen. Testing shall be performed on a complete generator assembly and load shall be applied through the generators receptacle panel. If a generator is equipped with a system that provides different engine operating modes such as a fuel economy mode, the generator shall be tested to this Section in all available modes. CO emission performance shall be determined by the highest weighted CO emission rate calculated in paragraph (e) of this section.

(1) Place the generator assembly in front of the CVS tunnel with the exhaust facing towards the collector. Connect the load bank and apply a load greater than 60 percent of the manufacturer's rated continuous power for a minimum of 20 minutes to warm the generator to operating temperature.

(2) Adjust the load bank to apply the appropriate mode calculated from the maximum generator load. Modal testing shall be performed in order from mode 1 to mode 6. Mode points are determined by a percentage of the maximum generator load:

(i) Mode 1: 100 percent of maximum generator load
(ii) Mode 2: 75 percent of maximum generator load
(iii) Mode 3: 50 percent of maximum generator load
(iv) Mode 4: 25 percent of maximum generator load
(v) Mode 5: 10 percent of maximum generator load
(vi) Mode 6: 0 percent of maximum generator load

(3) Stabilize oil and head temperatures by operating at mode for 5 minutes. After the 5 minute stabilization period, record emissions for at least 2 minutes at a minimum rate of 0.1 Hz with the prescribed mode applied. Record the mean CO emission value for that mode during the data acquisition period.

(4) Repeat steps in paragraphs (d)(2) to (d)(4) for the successive modes listed in paragraph (d)(2).

(5) When all modal mean CO emission rates have been determined, calculate and report the weighted CO emission rate using guidance in paragraph (e).

(e) *Weighted CO emission rate calculation and reporting.*

(1) Calculate the weighted CO emission rate using the mean CO emission rates determined in paragraph (d).

$$\dot{m}_w = 0.09 \times \dot{m}_1 + 0.20 \times \dot{m}_2 + 0.29 \times \dot{m}_3 + 0.30 \times \dot{m}_4 + 0.07 \times \dot{m}_5 + 0.05 \times \dot{m}_6$$

Where,

$\dot{m}_w$ = Weighted CO emission Rate (g/hr)
$\dot{m}_1$ = Mean CO emission Rate at Mode 1 (g/hr)
$\dot{m}_2$ = Mean CO emission Rate at Mode 2 (g/hr)
$\dot{m}_3$ = Mean CO emission Rate at Mode 3 (g/hr)
$\dot{m}_4$ = Mean CO emission Rate at Mode 4 (g/hr)
$\dot{m}_5$ = Mean CO emission Rate at Mode 5 (g/hr)
$\dot{m}_6$ = Mean CO emission Rate at Mode 6 (g/hr)

(2) Report the following results for the generator:

(i) Weighted CO emission rate in grams per hour.

(ii) Modal information including the mean CO emission, and head and oil temperature.

(iii) Maximum generator load information as determined in paragraph (c). Include maximum generator load, voltage, amperage, and frequency.

§ 1241.5 Prohibited stockpiling.

(a) *Base period.* The base period for portable generators is any period of 365 consecutive days, chosen by the manufacturer or importer, in the 5-year period immediately preceding the promulgation of the final rule.

(b) *Prohibited acts.* Manufacturers and importers of portable generators shall not manufacture or import portable generators that do not comply with the requirements of this part in any 12-month period between (date of promulgation of the rule) and (effective/compliance date of the rule) at a rate that is greater than 125% of the rate at which they manufactured or imported portable generators with engines of the same class during the base period for the manufacturer.

§ 1241.6 Findings.

(b) *General.* In order to issue a consumer product safety standard under the Consumer Product Safety Act, the Commission must make certain findings and include them in the rule. 15 U.S.C. 2058(f)(3). These findings are discussed in this section.

(c) *Degree and nature of the risk of injury.* Carbon monoxide is a colorless, odorless, poisonous gas formed during incomplete combustion of fossil fuels, such as the fuels used in engines that power portable generators. Mild CO poisoning symptoms include headaches, lightheadedness, nausea, and fatigue. More severe CO poisoning can result in progressively worsening symptoms of vomiting, confusion, loss of consciousness, coma, and ultimately, death. The high CO emission rate of current generators can result in situations in which the COHb levels of exposed individuals rise suddenly and steeply, causing them to experience rapid onset of confusion, loss of muscular coordination, and loss of consciousness.

(1) As of May 21, 2015, CPSC databases contained reports of at least 751 generator-related consumer CO poisoning deaths resulting from 562 incidents, which occurred from 2004 through 2014. Due to incident reporting delays, statistics for the two most recent years, 2013 and 2014, are incomplete, because data collection is still ongoing, and the death count most likely will increase in future reports.

(2) Based on NEISS, the Commission estimates that for the 9-year period of 2004 through 2012, there were 8,703 CO injuries seen in emergency departments (EDs) associated with portable generators. The Commission considers this number to represent a lower bound on the true number of generator-related CO injuries treated in EDs from 2004–2012. According to Injury Cost Model (ICM) estimates, there were an additional 16,660 medically-attended CO injuries involving generators during 2004–2012.

(d) *Number of consumer products subject to the rule.* For the U.S. market for the years 2010 through 2014, about 6.9 million gasoline-powered portable generators were shipped for consumer use, or an average of about 1.4 million units per year. Shipments of nearly 1.6 million units in 2013 made it the peak year for estimated sales during this period. Consumer demand for portable generators from year-to-year fluctuates with major power outages, such as those caused by tropical or winter storms. Portable generators purchased by consumers and in household use generally range from under 1 kW of rated power up to perhaps 15 kW of rated power. In the last 10 to 15 years, the U.S. market has shifted towards smaller, less powerful units.

(e) The *need of the public for portable generators and the effects of the rule on their utility, cost, and availability.* Portable generators that are the subject of the proposed standard commonly are purchased by household consumers to provide electrical power during emergencies (such as during outages caused by storms), during other times when electrical power to the home has been shut off, when power is needed at locations around the home without access to electricity, and for recreational activities (such as during camping or recreational vehicle trips).

(1) The proposed rule is based on technically feasible CO emission rates, so that the function of portable generators is unlikely to be adversely affected by the rule. There may be an effect on the utility of portable generators to the extent consumers are unable to purchase generators due to increased retail prices. There may be a positive change in utility in terms of fuel efficiency, greater ease of starting, product quality, and safety of portable generators.

(2) In terms of retail price information, the Commission's review found that generators with handheld engines ranged in price from $133 to $799, with an average price of about $324. Generators with non-handheld Class I engines had a wide price range, from $190 to over $2,000, with an average price of $534. Generators with one-cylinder Class II engines ranged in price from $329 to $3,999 with an average price of $1,009. Generators with two-cylinder Class II engines ranged in price from $1,600 to $4,999 and the average price of these units was $2,550.

(3) Aggregate estimated compliance costs to manufacturers of portable generators average approximately $113 per unit for engine and muffler modifications necessary to comply with the CO emission requirements of the proposed standard. The net estimated manufacturing costs per unit to comply with the proposed standard is $114 for handheld engines, $113 for Class I engines, $110 for Class II, one cylinder engines, and $138 for Class II, two cylinder engines.

(4) The expected product modifications to produce complying generators (EFI & catalysts) are available to manufacturers, and the Commission does not have any indication that firms would exit the market because of the rule. Therefore, the availability of portable generators would not likely be affected by the rule.

(f) *Other means to achieve the objective of the rule, while minimizing the impact on competition and manufacturing.* The Commission considered alternatives to achieving the objective of the rule of reducing unreasonable risks of injury and death associated with portable generators. For example, the Commission considered less stringent CO emission rates for portable generators; however, the Commission found that cost savings from less-stringent CO emission requirements likely would be less than expected reductions in the benefits, so that the net benefits of the rule probably would decrease under this regulatory alternative. The Commission also considered including an option for reducing CO emissions through use of automatic shutoff systems, which could potentially reduce the impact of the proposed rule by providing an additional option for complying with the proposed rule; however, because of unresolved issues concerning an automatic shutoff, the Commission does not believe that a regulatory alternative based on automatic shutoff technology instead of reduced emissions is feasible for hazard reduction at this time.

(g) *Unreasonable risk.*

(1) As of May 21, 2015, CPSC databases contained reports of at least 751 generator-related consumer CO poisoning deaths resulting from 562 incidents, which occurred from 2004 through 2014. Due to incident reporting delays, statistics for the two most recent years, 2013 and 2014, are incomplete, because data collection is still ongoing, and the death count most likely will increase in future reports.

(2) Based on NEISS, the Commission estimates that for the 9-year period of 2004 through 2012, there were 8,703 CO injuries seen in emergency departments (EDs) associated with portable generators. The Commission considers this number to represent a lower bound on the true number of generator-related CO injuries treated in EDs from 2004–2012. According to Injury Cost Model (ICM) estimates, there were an additional 16,660 medically-attended CO injuries involving generators during 2004–2012.

(3) The Commission estimates that the rule would result in aggregate net benefits of about $145 million annually. On a per-unit basis, the Commission estimates the present value of the expected benefits per unit for all units to be $227; the expected costs to manufacturers plus the lost consumer surplus per unit to be $116; and the net benefits per unit to be $110. The Commission concludes preliminarily portable generators pose an unreasonable risk of injury and finds that the proposed rule is reasonably necessary to reduce that unreasonable risk of injury.

(g) *Public interest.* This proposed rule is intended to address an unreasonable risk of injury and death posed by portable generators. The Commission believes that adherence to the requirements of the proposed rule will reduce portable generator deaths and injuries in the future; thus, the rule is in the public interest.

(h) *Voluntary standards.* The Commission is aware of two U.S. voluntary standards that are applicable to portable generators, UL 2201—*Safety Standard for Portable Generator Assemblies,* and ANSI/PGMA G300–2015—*Safety and Performance of Portable Generators.* These standards include the same requirements set forth mandatory CPSC portable generator label but do not otherwise address the risks related to CO poisoning. The Commission does not believe the standards are adequate because they fail to address the risk of CO hazard beyond the CPSC mandatory labeling requirement. The Commission is unaware of any portable generator that has been certified to either of the standards, and as such it is unlikely whether there would be substantial compliance with it if CO emissions requirements were incorporated.

(i) *Relationship of benefits to costs.* The aggregate annual benefits and costs of the rule are estimated to be about $298 million and $153 million, respectively. Aggregate net benefits from the rule, therefore, are estimated to be about $145 million annually. On a per unit basis, the Commission estimates the present value of the expected benefits per unit for all units to be $227. The Commission estimates the expected costs to manufacturers plus the lost consumer surplus per unit to be $116. Based on this analysis, the Commission finds preliminary that the benefits expected from the rule bear a reasonable relationship to the anticipated costs of the rule.

(j) *Least burdensome requirement that would adequately reduce the risk of injury.* (1) The Commission considered less-burdensome alternatives to the proposed rule on portable generators, but concluded preliminary that none of these alternatives would adequately reduce the risk of injury.

(2) The Commission considered not issuing a mandatory rule, but instead relying upon voluntary standards. As discussed previously, the Commission does not believe that either voluntary standard adequately addresses the CO risk of injury and death associated with portable generators. Furthermore, the Commission doubts that either of the

voluntary standards would have substantial compliance by industry.

(3) Excluding portable generators with two cylinder, Class II engines from the scope of the rule. The Commission estimates that net benefits of the proposed rule range from about $100 to about $140 per generator for the models with handheld, Class I and one-cylinder Class II engines. However, net benefits were negative $135 for the models with two-cylinder class II engines. Consequently, excluding portable generators with two cylinder Class II engines would result in a less burdensome alternative. However, it is possible that exclusion of generators with two-cylinder Class II engines from the scope of the rule could create an economic incentive for manufacturers of generators with larger one-cylinder engines to either switch to two-cylinder engines for those models, or if they already have two-cylinder models in their product lines, they could be more likely to drop larger one-cylinder models from their product lines. Because the Commission lacks more specific information on the generators with Class II twin cylinder engines, the Commission is proposing this rule with the broader scope of including these generators.

(4) The Commission considered higher allowable CO emission rates, which might result in costs savings from lower costs associated with catalysts (if they would not be required, or if less-costly materials could suffice), less-extensive engine modifications (other than EFI-related costs) and less-extensive generator housing modifications (if housing enlargement and other retooling would be minimized). However, based on Commission estimates, it seems likely that cost savings from less-stringent CO emission requirements would be less than expected reductions in benefits. Therefore, the Commission is not proposing this less burdensome alternative.

Dated: November 3, 2016.

Todd A. Stevenson,

Secretary, Consumer Product Safety Commission.

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