UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

**VOTE SHEET**

DATE: OCT 11 2006

**TO:** The Commission
Todd A. Stevenson, Secretary

**THRU:** Patricia M. Semple, Executive Director

**FROM:** Page C. Faulk, General Counsel
Jeffrey R. Williams, Assistant General Counsel
Barbara E. Parisi, Attorney

**SUBJECT:** Portable Generators: Legal Memorandum and Staff Briefing Package for ANPR

The Office of General Counsel recommends that the Commission instruct the staff to prepare a draft advance notice of proposed rulemaking (ANPR) for Commission consideration concerning portable generators. The legal memorandum and staff briefing package are attached.

Please indicate your vote:

I. Instruct the staff to prepare a draft ANPR in accordance with the staff recommendation for consideration by the Commission.

Signature ______________________ Date ______________

II. Instruct the staff to prepare a draft ANPR in accordance with the staff recommendation with changes for consideration by the Commission. (Please specify.)

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Signature ______________________ Date ______________

III. Do not instruct the staff to prepare a draft ANPR.

____________________ ________________

Signature Date

IV. Take other action. (Please specify.)

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Signature Date

STAFF REVIEW OF PORTABLE GENERATOR SAFETY

For Further Information Contact:
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## TABS

TAB Z (FOUO) Buyer, Janet, *Summary of Relevant Information Learned From Office of Compliance's Closed Meetings with Generator Manufacturers*, CPSC Memorandum to Jacqueline Elder, Assistant Executive Director, Office of Hazard Identification and Reduction, U.S. Consumer Product Safety Commission, Washington, D.C., February 14, 2006. 266

**ACKNOWLEDGEMENTS**

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## EXECUTIVE SUMMARY

In October 2005, then-Chairman Stratton directed the staff of the U.S. Consumer Product Safety Commission (CPSC) to conduct a thorough review of portable generator safety. This review addresses various aspects of improving generator safety, with particular emphasis on reducing the carbon monoxide (CO) poisoning hazard.

Portable generators are useful products, offering a means of providing electrical power to locations that either temporarily lack it or are not provided with electrical service at all. However, there are risks associated with their use, including CO poisoning, shock and electrocution, fire, and thermal contact burns. The overwhelming majority of generator-related deaths reported to CPSC are due to non-fire CO poisoning. From 1990 through 2005, CPSC has reports of at least 369 generator-related deaths; 351 are due to CO poisoning. If CO poisoning deaths from all consumer products are considered, the percentage of estimated CO poisoning deaths specifically associated with generators has been increasing annually since 1999.

Based on the most recent CPSC staff analysis of the in-depth investigations (IDI) staff conducted on fatal incidents, the majority of reported CO deaths associated with generators occurred during the winter months at a home location, including in a garage or shed at the residence. In 146 deaths that occurred at home, the majority resulted when the generator was operated in the basement/crawlspace, garage/enclosed carport, or living space of the home. Fear of generator theft and concern about noise to neighbors were two of the most common reasons mentioned for using the generator indoors when a reason was given. At least five deaths occurred when the generator was operated outside the home near an open window, door, or vent that allowed CO to enter the home.

The estimated number of portable generators in U.S. household use ranged from about 9.2 million units in 2002 to 10.6 million units in 2005. An estimated 1.1 million portable generators were purchased by consumers in 2003, 1.5 million were purchased in 2004, and 1.1 million were purchased in 2005. Approximately 40% of the portable units purchased by consumers in these three years were in the 5.0 kilowatt (kW) to less than 6.5 kW power output range. Nearly all (98.7%) portable generators sold in 2003-2005 were fueled by gasoline.

Staff believes there are strategies that can be considered for reducing the CO poisoning hazard. Requirements for weatherization features for portable generators may be one such strategy so that conflicting hazard avoidance instructions regarding the electrocution hazard can potentially be eliminated. Electrocution warnings typically instruct the user to keep the generator dry and out of damp conditions. Yet these conditions commonly exist when an ice storm or hurricane has caused a power outage, prompting the consumer to use a generator. Test requirements to verify the engine's ability to operate in cold, damp weather that causes icing could also be considered. Features that can deter generator theft and reduce engine noise, which are common reasons that have been identified in the incident data for improper generator placement, can also be considered.

Staff believes that the feasibility of performance requirements to substantially reduce consumer exposure to CO should be pursued. Examples include reducing the generator engine's

CO emission rate or through use of sensors that can detect hazardous ambient CO levels and shut off the generator in time to prevent serious injury or death.

A 5.5 kW generator can produce CO at rates nominally between 450 to 1,000 times that of the rate of CO production of various idling cars meeting current EPA automotive emissions standards. Technical approaches to limit CO production by large spark-ignition engines have been successful with automotive engines and marine generator engines. The technologies used on these engines, catalytic exhaust after-treatment and fuel injection, are also currently used on motorcycles in the U.S. and catalytic converters alone, without fuel injection, are used on small displacement 2-stroke and 4-stroke engines on motorscooters in countries such as China and India. The California Air Resources Board is proposing, and the Environmental Protection Agency intends to propose, rulemaking that will regulate the hydrocarbons (HC) and nitrous oxides (NOx) emissions of the class of engines that encompasses those used on portable generators that consumers typically own. Staff is aware that some engine manufacturers will meet these proposed rules by using catalytic converters. Experts indicate that they believe that catalytic exhaust after-treatment and fuel injection can be engineered for adaptation to engines on portable generators to reduce CO emissions by up to 95% with means to manage the expected higher exhaust temperature. Staff estimates that if a CO reduction on this order could be achieved, it would significantly improve the survivability of many of the victims for the scenarios described in the incident data. Staff believes that the appropriate research should be performed to demonstrate whether generator performance requirements to protect consumers against the hazard of acute residential CO exposures that can result in death or serious and/or lasting adverse health effects in exposed individuals are technically feasible and practical. Some industry representatives have indicated that, while not impossible, technical solutions would be challenging and costly to develop.

Other strategies considered by CPSC staff are a private sector consortium and information and education campaigns. A national education program may have an immediate impact on reducing the number of CO poisonings associated with portable generators, particularly those already in consumers' hands or in retailers' and manufacturers' inventories.

There are no existing voluntary standards that address the CO poisoning hazard of portable generators beyond warnings. Underwriters Laboratories (UL) is in the process of developing the first edition of UL 2201 *Portable Engine-Generator Assemblies*. Because it may take some time to achieve consensus on this draft proposed standard, UL recently issued an Outline of Investigation for portable generators. This document establishes the requirements with which a product must conform in order to be eligible to bear the UL Listing Mark; it is not currently a consensus standard. UL's Outline of Investigation includes requirements for warnings as well as features that will provide protection against electrocution and shock during use in wet weather. However, it does not address consumer exposure to unsafe CO emissions through performance requirements.

Staff recommends that the Commission initiate rulemaking to pursue additional regulatory options by publishing an advance notice of proposed rulemaking (ANPR) for public comment. The ANPR should address rulemaking (including establishing mandatory generator performance standards) as well as non-regulatory options such as information and education campaigns, a private sector consortium, and any other potential approach available to the Commission.

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

**Memorandum**

Date: OCT 11 2006

TO : The Commission
Todd Stevenson, Secretary

THROUGH : Page Faulk, General Counsel
Patricia Semple, Executive Director

FROM : Jacqueline Elder, Assistant Executive Director
Office of Hazard Identification and Reduction

Janet Buyer, Project Manager
Directorate for Engineering Sciences

SUBJECT : Staff Review of Portable Generator Safety

REF : Memorandum from Hal Stratton, Chairman, to Patricia Semple, Executive Director, "Review of Portable Generator Safety," October 12, 2005

## I. Introduction

Staff of the U.S. Consumer Product Safety Commission (CPSC) conducted a thorough review of portable generator safety in response to then-Chairman Stratton's memorandum of October 12, 2005 **(TAB A)**.* This briefing package addresses various aspects of improving generator safety, with particular emphasis on reducing the carbon monoxide (CO) poisoning hazard. This package provides death and incident data, information regarding estimates of injuries and fires, market information, societal cost data, strategies for reducing CO deaths associated with portable generators, cost estimates, an analysis of current applicable voluntary standards, and a summary discussion with staff recommendations.

## II. Background

While generators pose four main hazards (CO poisoning, shock and electrocution, fire, and thermal contact burns), the staff's focus with this product has primarily been on the CO poisoning hazard because the majority of generator-related deaths reported to CPSC are associated with this particular hazard. One of CPSC's strategic goals is to reduce the rate of non-fire CO poisoning deaths associated with consumer products by 20% from the average number for the years 1999 and 2000 by the year 2013.

* In accordance with 16 C.F.R. §1031.11(b), the Commission is advised that Janet Buyer, the principal author of this memorandum, participated in Underwriters Laboratories voluntary standard activities concerning portable generators.



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NOTE: This document has not been reviewed or accepted by the Commission.
Initial ___ Date 10/11/06

Since 1999, the percentage of estimated CO poisoning deaths specifically associated with generators has been increasing annually. The total yearly estimated non-fire related CO deaths for each of the years 1999 through 2002 for all products are 109, 138, 130 and 188, respectively. In 1999, generators were associated with 7 (6%) of the total yearly estimated CO poisoning deaths for that year. In 2000, 2001 and 2002, they were associated with 19 (14%), 22 (17%) and 46 (24%) deaths out of the total estimates for each of those years.[†,1] Reducing the number of CO poisoning deaths associated with generators is critical for CPSC to meet its strategic goal.

The risk of CO poisoning associated with generators appears to be relatively high compared to other consumer products. For instance, of the estimated 188 CO poisoning deaths that were associated with consumer products in 2002, 11% were associated with natural gas-fired heating systems and 24% were associated with generators. CPSC staff estimates that about 9.2 million portable generators were in use in U.S. households in 2002 (**TAB B**). In contrast, a survey by the Energy Information Administration estimates that 60.5 million U.S. households used natural gas for space heating purposes in 2001. Furthermore, considering the amount of time or days per year a consumer may use a portable generator relative to the daily or seasonal use of other combustion appliances, the relative risk appears to be high from this perspective as well.

## III. Product Information

Portable generators are useful products because they offer a means of providing electrical power to a location that either temporarily lacks it or is not provided with electrical service at all. A portable generator has an internal combustion engine to produce rotational energy, which is used to generate electricity. The engine may be fueled by gasoline, diesel fuel, natural gas, or liquid propane and it is this engine that is the source of CO. There are 120-volt receptacle outlets, and possibly 240-volt receptacle outlets as well, on the generator to provide power to individual appliances when plugged into the receptacles, either directly or with extension cords. Some models also have a 12-volt direct current (DC) battery charging circuit. As an alternative to cord-connecting appliances to the generator receptacles, the generator output can be connected to the household branch circuit wiring using a professionally installed transfer switch. See Figure 1. **TAB C** has a more detailed description of how this arrangement works.

[†] Superscripted numbers refer to references listed at the end of this memorandum.

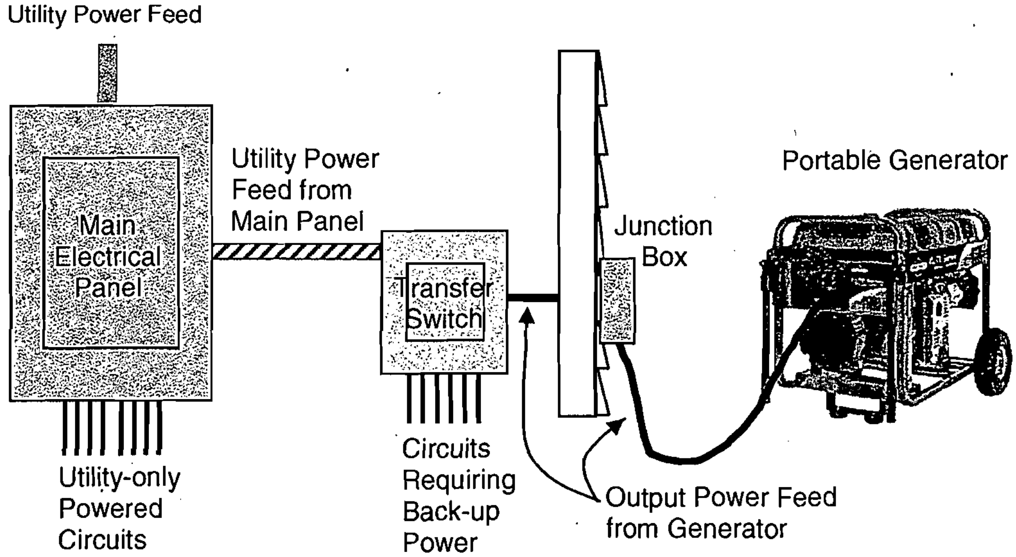


**Figure 1: An example of a typical transfer switch setup for properly interfacing a portable generator with the installed household wiring.**

## IV. Generator-Related Death Data

From 1990 through 2005, CPSC has reports of at least 369 generator-related deaths. The distribution by year and hazard is provided in Table 1. The overwhelming majority of deaths associated with generators is due to non-fire CO poisoning. As of June 1, 2006, 351 generator-related CO poisoning deaths have been reported to CPSC for the years 1990 through 2005 **(TAB D)**. Ten electrocution deaths and eight fire-related deaths were reported to CPSC for this sixteen-year period as of November 4, 2005, and December 7, 2005, respectively **(TAB E)**. Since some deaths are reported to CPSC months or years after an incident occurred, counts for the more recent years may not be as complete as counts for earlier years. Reporting of generator-related deaths is not a statistical sample nor a complete census of incidents. However, the increase in reported CO poisoning incidents occurring since 1999 indicates an actual increase in such incidents since CPSC has not changed data collection procedures.

CPSC staff analyzed the data in detail for those generator-related CO poisoning deaths that occurred in 1990 through 2004 and were entered in the CPSC databases as of June 27, 2005 **(TAB D)**. There were 274 deaths, which occurred in 203 separate fatal incidents, reported to CPSC by that date for that fifteen-year period. Of the 274 reported deaths, 39% occurred in the winter, 26% in the fall, 20% in the summer, and 14% in the spring. Seventy-four percent of the deaths occurred when the generator was used at a home location, which includes single-family homes, apartments, and mobile homes as well as garages or sheds at homes or residences. Fifteen percent of the deaths occurred at a temporary shelter; this category includes trailers, horse trailers, motor homes, recreational vehicles, vans, cabins, and campers. The remaining 11% of the deaths occurred on a boat, at an unreported location, or at some other location.

CPSC staff conducted in-depth investigations (IDIs) on 137 of the 203 fatal generator-related incidents, which involved 189 of the 274 reported deaths. Some of the information from these IDI reports includes the following:

- For 60 deaths it was reported that the generator was used because there was a weather-induced power outage or problem with power distribution.
- 146 deaths occurred at home and the majority of these occurred when the generator was operated in the basement/crawlspace, garage/enclosed carport, or living space of the home.
- Two of the most common reasons mentioned for using the generator indoors were fear of generator theft and concern about noise to neighbors. (The reason a generator was used in a certain location was given in IDIs for only 32 deaths.)
- For 24 deaths, it was reported that there was an open window, an open door, an open garage door, or a combination of these where the generator was operated.
- In at least five deaths it was reported that the generator was operated outside the home near an open window, door, or vent.
- Almost all of the generators were referred to as gas or gasoline generators.

**Table 1: Distribution of Generator-Related Deaths Reported to CPSC by Year and Hazard, 1990 through 2005**

| Year | CO Deaths[A,B] | Electrocution Deaths[C] | Fire-Related Deaths[D] |
|---|---|---|---|
| **Total** | **351** | **10** | **8** |
| 1990 | 18 | 1 | 0 |
| 1991 | 3 | 0 | 0 |
| 1992 | 7 | 1 | 0 |
| 1993 | 11 | 1 | 1 |
| 1994 | 5 | 1 | 1 |
| 1995 | 10 | 0 | 2 |
| 1996 | 17 | 1 | 1 |
| 1997 | 18 | 1 | 0 |
| 1998 | 13 | 1 | 0 |
| 1999[E] | 6 | 0 | 0 |
| 2000 | 20 | 0 | 0 |
| 2001 | 18 | 0 | 0 |
| 2002 | 43 | 0 | 2 |
| 2003 | 56 | 0 | 0 |
| 2004 | 42 | 1 | 0 |
| 2005 | 64 | 2 | 1 |

[A] For the period of 1/1/1990 through 12/31/2001, these are the number of deaths in the CPSC databases as of 6/27/2005 (**TAB D**).

[B] For the period of 1/1/2002 through 12/31/2005, these are the number of deaths in the CPSC databases as of 6/1/2006 (**TAB D**).

[C] According to the CPSC databases as of 11/4/2005, these deaths occurred between 1/1/1990 and 11/4/2005 (**TAB E**).

[D] According to the CPSC databases as of 12/7/2005, these deaths occurred between 1/1/1990 and 12/7/2005 (**TAB E**).

[E] In 1999, the Tenth Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) was implemented. With the transition to ICD-10, the types of death certificates purchased by CPSC changed. Prior to 1999, CO deaths associated with generators were normally coded with an ICD-9 e-code 868.2 (CO deaths associated with exhaust from motor vehicle [not in transit], farm tractors, gas engines, motor pumps, and any other type of combustion engine not in watercraft). CPSC did not routinely purchase death certificates with e-code 868.2 since the majority of deaths with this code were automobile exhaust-related deaths which are not within CPSC's jurisdiction. Occasionally, some death certificates that were related to generators and CO poisoning were reported to CPSC under other e-codes, (usually under e-codes 868.8 [carbon monoxide from other sources] and 868.9 [unspecified carbon monoxide]). In January 1999, CPSC began purchasing death certificates classified in ICD-10 codes that contain all unintentional CO poisoning deaths associated with all sources of carbon monoxide, including motor vehicles (**TAB D**).

## V. Estimates of Generator-Related CO, Shock, and Burn Injuries And Estimates of Fires and Fire-Associated Injuries and Losses

Although there are serious CO poisoning injuries associated with generators, some of the less severe CO injuries seen in hospital emergency rooms can be difficult to distinguish from common non-fatal illnesses. CPSC injury estimates are based on injuries treated in the emergency rooms of hospitals participating in the National Electronic Injury Surveillance System (NEISS), a probability sample of about 100 U.S. hospitals. NEISS cases involving CO poisoning can vary in severity, from an individual receiving a precautionary examination due to activation of a CO alarm to an individual receiving treatment in a hyperbaric oxygen chamber. There is likely a continuum of emergency room visits associated with a CO exposure that includes those that are precautionary in nature, those that are symptomatic in nature, and those that require extensive medical treatment. CPSC staff does not develop CO injury estimates because it is not possible to make distinctions among CO emergency room visits based on severity due to lack of the necessary detail available in individual NEISS records. CPSC staff recently has sought to improve data quality by requesting that CO blood concentration levels, measured as carboxyhemoglobin (COHb), be included in the NEISS data collection whenever possible.[3]

Individuals who survive serious prolonged COHb elevations (usually above 20% COHb) may ultimately suffer from the phenomenon of delayed neurological sequelae (DNS) (**TAB F**).[4] DNS is typically manifested within a few days or weeks after the apparent recovery from the initial CO exposure. Symptoms can include emotional instability, memory loss, dementia, psychosis, Parkinsonism, incontinence, blindness, paralysis, and peripheral neuropathy. Symptoms of DNS may respond to hyperbaric oxygen therapy and/or may resolve spontaneously over a two-year period, but victims exhibiting the most severe symptoms such as Parkinsonism, blindness, and paralysis are often permanently affected. While loss of consciousness is typically associated with more serious outcomes, it is not necessary to have lost consciousness to sustain DNS from CO exposures. CPSC does have reports of victims who survived a CO exposure with a reported COHb level in excess of 20%; however, CPSC does not conduct follow-up interviews with victims at significantly later times after exposure to inquire about their long-term outcome.

Regarding shock and fire or burn-related injuries associated with generators, the number of these incidents that are treated in the emergency rooms of hospitals participating in NEISS is so small that the national estimates for these injuries are likely to be statistically unreliable.

Based on the latest available data from the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's annual survey of fire losses, it is estimated that there were 100 fires involving generators in 2002. Associated with these fires, it is estimated that there were 10 injuries and $3.0 million in property and content loss. It is possible that these are underestimates since, in 2002, only 70% of the data was coded in the new NFIRS version (5.0) which allowed for the identification of generators as the equipment involved in ignition. On the other hand, since the percentage of incidents that specifically involved portable generators is unknown, it is also possible that these estimates are high. The estimates pertain to unintentional, residential structure fires, resulting in civilian injuries. The above fire estimate was rounded up to the nearest 100, the injury estimate was rounded to the nearest 10, and the property/content loss was rounded to the nearest tenth of a million dollars **(TAB G)**.

## VI. Market Information

Staff estimates that the total number of generators, both fixed (stationary) and portable, in household use ranged from about 9.9 million units in 2002 to 11.4 million units in 2005 **(TAB B)**.[5] About 93% of generators purchased by consumers in recent years have been portable, and about 7% have been fixed units.[6] Assuming this proportion applies to ownership of units, the estimated number of portable generators in household use ranged from about 9.2 million units in 2002 to 10.6 million units in 2005.

Estimated retail sales of generators to consumers totaled approximately 1.2 million units in 2003, 1.6 million units in 2004, and 1.2 million units in 2005. Based on the proportion of generators purchased by consumers that were portable versus fixed units, an estimated 1.1 million portable generators were purchased by consumers in 2003, 1.5 million were purchased in 2004, and 1.1 million were purchased in 2005. Approximately 40% of portable units purchased by consumers in these three years were in the 5.0 kilowatts (kW) to less than 6.5 kW power output range. This includes the size range of units involved in most of the fatal incidents that CPSC staff investigated in which the rating of the involved generator was identified **(TAB D)**. Nearly all (98.7%) portable generators sold in 2003-2005 were fueled by gasoline. Fixed generators were less likely to be fueled by gasoline.

## VII. Societal Cost Estimates Associated with Generator-Related CO Poisoning Deaths

Staff has estimated the societal cost of generator-related CO deaths **(TAB B)**. The average number of deaths reported to CPSC for the years 2002 through 2005, as provided in Table 1, is 51. These are the years in which staff has sufficient data available to estimate the number of portable generators in household use. Based on a $5 million value of a statistical life, the average annual societal cost of these deaths is estimated to be about $256 million. The estimated annual societal cost per generator, assuming an estimated average population of 10.4 million generators in U.S. households for the years 2002 through 2005, is $24.56. Based on a 7-year expected product life, the present value of expected societal cost of CO poisoning deaths is estimated to be about $157 per generator. Since these costs are based on death reports received by the CPSC, actual societal costs may be higher, to the extent that incidents do not come to the attention of CPSC.

The benefits associated with safety interventions would depend on the effectiveness of those measures. For every 10% reduction in the hazard resulting from an intervention, benefits of almost $16 per generator would be expected. For example, an intervention that is 50% effective would result in estimated benefits of about $79 per generator and an intervention that is 75% effective would have expected benefits of about $118 per generator.

Because staff does not make CO injury estimates as explained above, staff did not estimate the societal cost related to CO injuries. However, significant societal costs may be incurred by some individuals who survive serious prolonged COHb elevations. Thus, additional societal costs from non-fatal CO poisoning would increase the overall societal cost that might be addressable by interventions, with corresponding additional expected benefits.

## VIII. Possible Strategies to Address the CO Poisoning Hazard

### A. Weatherization Requirements

Portable generators that consumers typically use are not constructed to permit safe use in damp conditions because their electrical components and connections are not protected. They typically include electrocution warnings that instruct consumers to keep the generator dry and out of damp conditions **(TAB H)**. However, power outages that can lead to the use of a generator are commonly caused by weather conditions, such as ice storms and hurricanes, that result in damp conditions which may linger after the initial period of precipitation has passed. Furthermore, staff found that generators typically have CO poisoning warnings that do not advise against indoor generator use. Instead, they advise to not use the generator in a confined or enclosed space and to provide proper ventilation. **(TAB I)**. None of the warnings staff observed defined what is considered a "confined or enclosed space" or "proper ventilation." Prior research has concluded, however, that tools with gasoline-powered engines produce CO that "can rapidly accumulate, even in areas that appear to be well-ventilated, resulting in dangerous and fatal concentrations within minutes." [7,‡]

Since staff believes that generators should never be used indoors because of the risk of CO poisoning, there is an inherent conflict in the actions consumers should take in order to avoid both an electrocution hazard and the CO poisoning hazard when the generator is to be used in damp conditions. To address potential consumer confusion from these conflicting instructions, CPSC staff examined issues related to making portable generators weatherproof **(TAB J)**. Staff determined that to be weatherproof, a generator would need, as a minimum, a raintight or rainproof enclosure, in-use weatherproof receptacle covers, and ground fault protection for all receptacles. Although these features may be feasible, they may not necessarily be practical; e.g., the addition of an enclosure may affect the generator's size and portability. Also, these features alone may not universally eliminate the risk of electric shock for all models of portable generators in severe conditions. For example, areas that are normally dry could become subject to significant puddling or channeling of water in heavy or prolonged rainfall. Some generators that are physically small could become flooded from standing water if placed in such areas.

Some generators may also have another limitation of use during a time when they are frequently needed. Under certain weather conditions such as those that precipitate an ice storm (temperatures below 40°F [4°C] combined with high humidity), some generator engines may experience icing in the carburetor and/or the crankcase breather system, resulting in poor engine

‡ For instance, with a 5-hp 4-cycle engine running in a 2,332 $ft^3$ room, a ventilation rate of 5000 $ft^3$/min (120 air changes per hour) would be required to prevent the CO concentration from exceeding 200 ppm for short periods. For frame of reference, the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) recommends ventilation rates of 1 to 20 air changes per hour in commercial and public buildings. National Institute for Occupational Safety and Health (NIOSH) defines 200 ppm as a ceiling limit: "No level of carbon monoxide to which workers are exposed shall exceed a ceiling concentration of 200 ppm." (Source: NIOSH, Criteria for a Recommended Standard: Occupational Exposure to Carbon Monoxide. DHEW (NIOSH) Publication No. 73-11000, 1972.)

performance (**TAB K**). At least one fatality reported to CPSC documents a scenario where the engine repeatedly stalled outdoors during an ice storm and the consumer brought the generator into a doorway, and then later indoors, in order to keep it running.[§] It is unknown if or how much this operability problem may contribute to the fact that the majority of CO deaths associated with generators reported to CPSC occurred in December, January, and February. CO deaths and injuries associated with generators used during ice storms are well documented in published literature.[8-14]

B. Performance Requirements

Incident data collected by CPSC and data documented in the Centers for Disease Control and Prevention's (CDC) *Morbidity and Mortality Weekly Report*[15-17] show an established pattern of consumer death and injury from using portable generators indoors as well as outdoors near openings to occupied spaces. In order to get a better understanding of how quickly a typical generator-use scenario described in CPSC incident data could develop into a serious hazardous situation, CPSC staff conducted testing and modeling. This testing and modeling was used to estimate how much time it would take to create a lethal environment in different areas of a home if a 5.5 kW generator was operated in the basement with a full tank of gas until it ran out of fuel.

Staff tested two different models of commonly-available 5.5 kW portable generators to determine the rate at which each generated CO under various operating conditions. Some preliminary test results from one generator were then used in a computer model of a hypothetical two-story, four-bedroom home to determine the distribution of CO throughout the home as a function of time. Staff then modeled the CO time-course profiles to estimate CO uptake and formation of COHb levels in the blood of individuals located in different rooms of the home. (During early stages of CO exposure, the COHb level provides a rough estimate of poisoning severity.) The modeling study assumed the individuals were moderately active, e.g., performing non-strenuous household chores. It also considered the impact of the generator load and the operational status of the home's air circulation fan that is part of the heating/ventilating/air conditioning (HVAC) system.

Generalizing staff's estimates, individuals in the basement would likely be incapacitated within 30 to 40 minutes. Unless rescued, they would likely die 10 to 20 minutes later. Persons in the upper level bedrooms would likely be incapacitated in two and a half to four hours and, unless rescued, would likely die within approximately another hour (**TAB F**). Given that the 5.5

[§] In CPSC document number 030418HCC1477, it is stated that the consumer bought and operated a generator because of a power outage caused by an ice storm. He operated the generator outdoors but it stalled after some amount of time. So he alternated between running it in the doorway for 20 minutes at a time and then outdoors until it would stall, about 45-60 minutes at a time, for about 9 hours. After that, he operated it indoors with the door closed. His 46-year-old wife died and her 14-year-old daughter was hospitalized in the incident. In CPSC document number 030418HCC1461, it is stated that the victim had previous experience using his generator and had always operated it outdoors prior to the incident. During this incident, in which a power outage was caused by the same ice storm as that referenced in 030418HCC1477, the victim was using the generator in a 40'x40' utility building within a few feet of a fully opened side entrance door. Earlier in the day, the victim had one of the main bay doors open as well. In CPSC document number 021226HCC1277, a 79-year-old man died of CO poisoning from a generator that he used because of a power outage also caused by the same ice storm. He operated the generator on a sun porch.

kW generators that were tested each have a fuel tank capacity that enables the generator to run for 6 hours under full load, per the owner's manuals, all the occupants in the home would be expected to die unless rescued before the generator ran out of fuel. These findings are corroborated by CPSC's incident data since there are quite a number of fatal incidents in which it is documented that the generator was found to be out of fuel and still in a switched-on state (**TAB D**).

In addition to the testing that staff conducted to support this health hazard characterization, staff subsequently did more extensive testing on the two 5.5 kW generators as well as two other smaller models of generators (**TAB L**). This subsequent testing found higher CO generation rates for the 5.5 kW generators than was used in the modeling. These results would translate to even shorter time estimations for lethal CO exposures in the home that was modeled.

Staff believes that if performance requirements were to be developed, they should protect consumers against the hazard of acute residential CO exposures that can result in death or in serious and/or lasting adverse health effects in exposed individuals (**TAB M**). Furthermore, they should be technology blind (i.e., written such that they do not specify any particular technology) to allow manufacturers the option of multiple approaches, such as limiting the engine's CO emission rate during normal operation and/or using sensors. Sensors can be used in a number of different ways, one of which is to detect hazardous ambient CO levels and initiate signals to automatically shut off the generator engine and warn consumers of the developing hazard. Staff believes that performance requirements should be based on the likely CO hazard that would occur in a "realistic" home under conditions that are representative of consumer usage patterns seen in the incident data. Parameters that influence CO accumulation in, and dissipation from, residential settings must be considered in order to define a "realistic" home and foreseeable conditions.

1. Engines with Reduced CO Production

Staff believes that limiting the total amount of CO generated by portable generators is the most reliable way to limit consumer exposure to harmful CO levels. Technical approaches to limit CO production of large spark-ignition engines have been successful. The addition of catalytic converters to motor vehicles to address environmental concerns over ambient air quality has had a dramatic impact in reducing CO emissions in automotive engine exhaust. Beginning in 1975, automobile manufacturers began installing catalytic converters on automobiles in the U.S. in order to comply with EPA automotive emissions standards, which were set to meet the 1970 Clean Air Act. By 1981, new cars were being manufactured that met the amended Clean Air Act CO standard of 3.4 grams per mile (g/m), which was a 96% reduction in the CO emission rate of pre-1975 cars.[18] In spite of the fact that the resulting CO emission rate is still too high to safely run a car indoors, an analysis of the impact of these environmental policies on carbon monoxide-related mortality shows a decline in unintentional vehicle-related CO deaths of greater than 80% from 1975 through 1996.[19]

To give the reader a sense of perspective on the steady state CO emission rate of a small engine on a portable generator compared to that of an automotive engine (on a per unit of time basis, not per unit of power output basis), staff estimates that the 10 horsepower (hp) rated engine on one of the 5.5 kW generators tested by staff produces CO at rates nominally between 450 to 1,000 times that of the rate of CO produced by various cars, which meet EPA automotive emissions standards, while idling (**TAB N**).

CO poisonings caused by marine engines on houseboats have been under investigation by the National Institute for Occupational Safety and Health (NIOSH) since 2000. Five hundred seventy-one boat-related CO poisonings have been identified, with more than 200 of these attributed to houseboat generator exhaust. NIOSH has conducted many field investigations to document the ambient levels of CO from gasoline-powered generators on and around houseboats and the effect of engineering controls on reducing those levels.[20] Following these investigations, two major manufacturers of marine power generation systems have developed low CO emission generators. These manufacturers claim that the addition of technologies such as electronic fuel injection and catalytic converters have helped reduce the CO emissions by 99% (**TAB O**). Initial tests by NIOSH of one of these low CO emission systems have shown a 99.8% reduction of CO emissions on a recently installed system. Additional tests they performed on an installed generator (not one of the new low CO emission generators) retrofitted with an aftermarket fuel injection system showed a reduction in CO emissions greater than 99.1%.[21] NIOSH recommended additional testing to determine how the systems performed after a full season of rental use. While large water-cooled marine engines differ in a number of significant ways from the small air-cooled utility engines used on portable generators, outside technical experts have commented during meetings with CPSC staff that they believe the catalytic converter and electronic fuel injection technologies could be applied to the latter to significantly reduce CO emissions.

To explore the possible application of these and other technologies to portable generators, in March 2006, CPSC staff issued a Request for Information (RFI) to solicit ideas, data, and concepts on technical approaches that could substantially reduce the tailpipe CO emissions from portable gasoline engine-powered generators to levels that could reduce the number of CO poisoning deaths.

A total of nine respondents to the RFI proposed multiple approaches to address the hazard. Seven of the respondents identified catalytic exhaust after-treatment, alone or coupled with a fuel injection system, as a viable technique to reduce CO emissions. According to the respondents, using a fuel injection system greatly reduces the amount of unburned fuel in the exhaust, which would allow an oxidation catalyst to be used to reduce the amount of CO leaving the tailpipe without unmanageable heat buildup in the catalyst. They indicated that catalytic converters are used on small displacement 2-stroke and 4-stroke engines on motorscooters in countries such as China and India and that catalytic converters and fuel injectors are used on motorcycles in the U.S.[22-24] Staff is also aware that some small engine manufacturers will meet regulations being proposed by the California Air Resources Board (CARB), and those the EPA intends to propose, to reduce hydrocarbon (HC) and nitrous oxide (NOx) emissions of the class of engines that encompasses those used on consumer-grade portable generators by using catalytic converters. The RFI respondents asserted their beliefs that catalytic converters and fuel injectors can be engineered for adaptation on portable generators to not only meet these proposed (or intending to be proposed) regulations but also to specifically target CO emission reduction from the tailpipe in the range of 90% to 95%. They indicated that the exhaust temperature would rise as a result but stated their belief that the increase would be manageable to prevent an increase in the risk of fires and burns.

Two responders (one of whom also suggested catalysis) provided information on fuel additives which they stated would reduce CO production by improving combustion in the engine and limiting unburned fuel in the exhaust. This approach would require either that the consumer put the additive in the fuel or, alternatively, the addition of a reservoir with a metering system to inject the additive and a monitor to turn off the engine if the additive runs out.

Two responders provided information on new technologies or unconventional power supplies. One described a generator set powered by a Stirling cycle engine that, because of the operating principles, does not produce CO and has low exhaust temperatures. The Stirling engine concept has the potential to very substantially reduce CO production; however, staff considers that this approach may take much longer to develop into a viable solution. The other respondent proposed an undefined "bolt-on" device to be added to existing generators; however, the respondent provided no information on the technology or its effect on engine performance.

Based on the information received in response to the RFI, staff has issued a contract to investigate the application of catalytic exhaust after-treatment, coupled with off-the-shelf fuel injection/electronic control technologies, to substantially reduce CO emissions. The contractor is being asked to develop and demonstrate a prototype low CO-emitting small utility engine that would be used on a generator. Reduction of CO emissions in the 90% to 95% range will NOT be sufficient to permit safe generator use indoors. However, based on staff's modeling of a theoretical home (discussed above) with a 5.5 kW generator running in the basement, staff estimates that a reduction of around 92% in the generator's CO emission rate can likely result in a significant delay, and reduced severity, of the CO exposure in occupants located elsewhere in the house, outside the basement **(TAB P)**. This means that home occupants with intact faculties, who are not sleeping, may possibly have time to recognize that their developing symptoms are indicative of a hazardous exposure before being incapacitated and prevented from taking appropriate corrective actions. Furthermore, with such a significant reduction in CO emissions, depending on the occupant's location relative to the generator, there is a greater likelihood that they might be able to survive the CO exposure without any serious residual impact on their health, even if they did not leave the environment, such as could be the case for those asleep in upper level bedrooms. Additionally, reduced emissions of around 92% would be expected to be of even more significant benefit to consumer safety in situations where generator fumes infiltrate the home from the outdoors. Staff's exposure modeling predicts that survivability for the modeled scenario decreases significantly when CO emissions reductions are dropped below 85%.

In addition to the development work discussed above, staff has recently established an interagency agreement with the National Institute for Standards and Technology (NIST) to model the consumer use scenario with a generator operating in an attached garage. The results of this modeling may assist staff in determining what levels of CO reduction would help reduce the number of CO deaths when generators are operated in garages in various styles of homes under different ambient and situational conditions.

2. Interlocking Devices

Another option for reducing the risk of CO poisoning is the concept of a gas-sensing interlock device that will shut off an operating portable generator before it creates a hazardous CO environment. These types of systems are commercially available and advertised as being designed for the marine and recreational vehicle markets (**TAB R**). They may potentially be applied to portable generators. CPSC staff is investigating two approaches to this type of interlock concept. One is a CO detection and shutdown system that detects the level of CO in the vicinity of the generator. If CO levels near the generator become elevated, an automatic shut-off device could possibly be used to disable the generator. This concept is currently being evaluated by CPSC staff. An advantage of this approach is that it allows fast detection of CO when the generator is operated in an enclosed or partially enclosed area, before it infiltrates nearby areas. It also may require no, or minimal, user interaction. A disadvantage of this approach is that the CO sensor may impair the ability of the generator to run when properly operated outdoors if the exhaust accumulates or circulates around the generator. Also, the sensor reliability and life may be compromised when exposed to outdoor environmental conditions and engine vibration, combustion products, and heat.

The second approach involves a CO detection device that senses CO at a remote location away from the generator, where occupants might be, and shuts down the portable generator using wireless technology if an unsafe CO environment is developing there. Staff has conducted an initial proof-of-concept demonstration of this approach using off-the-shelf components including a residential CO alarm, a radio frequency receiver and transmitter, and a portable generator. The residential CO alarm integrated with a wireless link communicates with a receiver on the portable generator. In the event that elevated CO levels occur where the CO alarm is located, the generator will automatically shut down when the alarm activates. The unit was tested in various scenarios where the generator was operated in a confined space. A description of the design and testing of the functionality of the demonstration system is documented in a staff report, *Demonstration of a Remote Carbon Monoxide Sensing Automatic Shut Off Device for Portable Generators* (**TAB S**).

An advantage of this approach is that the CO sensor is ideally located near the occupants, where it is most critical for the CO level to be monitored, and where the sensor would not be exposed to outdoor environmental conditions as well as engine vibration and exhaust as with the approach discussed above. Also, the system can be configured to provide a manually-activated remote shutdown capability to prevent user exposure to the CO that may accumulate around the generator when he wants to turn the generator off. A disadvantage of this approach is that it requires user interaction with the system in order for it to work successfully. Proper placement of the sensor by the user in the most appropriate location is a critical factor. Since the staff's study was limited to an initial proof-of-concept of the technical aspects of this approach, it did not address the relationship of human factors aspects with the utility and effectiveness of the system. This as well as other issues such as durability, reliability, and environmental conditions that could affect performance would need to be carefully considered in the development of a practical system for consumer use.

It has been suggested that if portable generators were available to consumers with features to protect against the risk of CO poisoning, they could potentially create a false sense of security for the consumer and might perversely result in encouraging the consumer to run a portable generator indoors. In response to this, staff expects that manufacturers would provide better warnings than those observed on current portable generators **(TAB I)** that staff believes are inadequate, ambiguous, and may already encourage indoor generator use.[**] However, even if improved warning labels were on such a product, relevant human factors issues would need to be assessed. Lastly, staff does not expect that manufacturers would market their product as "safer" for liability reasons.

Some portable generator manufacturers currently provide minimum clearance requirements for placement of the generator in conjunction with instructions on how to avoid the CO poisoning hazard **(TAB T).** Staff understands that these distances are to allow for adequate combustion and cooling airflow and possibly to direct exhaust away from combustible surfaces. However, staff believes that when such a distance is included with the warnings or instructions pertaining to the CO hazard, it may mislead consumers into thinking that they can avoid exposure to the engine exhaust by following these instructions. Staff has also found pictures on some manufacturers' websites that depict operation of a generator immediately adjacent to an open door or window. An example is provided in **TAB T**. Federal agencies such as the Federal Emergency Management Agency (FEMA), the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA) provide guidance, perhaps based on these manufacturer-specified distances **(TAB U)**, but the recommended distances are not consistent with one another, and staff believes they may not be great enough to avoid the hazard. The Centers for Disease Control and Prevention have reported the results of a study of post-hurricane related generator use in 2005 that found up to 50% of non-fatal CO poisoning incidents involved generators operated outdoors but within one to seven feet from the home.[25] Furthermore, staff has found that some generator manufacturers recommend in their instruction manuals use of extension cords that are "as short as possible, preferably less than 15 feet long, to prevent voltage drop and possible overheating of wires" **(TAB T)**. Staff believes that encouraging use of short extension cords may result in placement of the generator too close to avoid CO infiltration into the home.

C. Additional Features to Discourage Improper Placement of an Operating Generator

Concern over generator theft and noise to neighbors have been identified in CPSC's incident data as two of the most common reasons mentioned for consumers using generators in or near their homes. Staff believes that if there are features available on or with generators that can adequately address these concerns, consumers may be less likely to operate their generators in improper locations. Examples of these features include means for securing the generator to deter theft and means for muffling the sound of the engine. Regarding the latter, the human factors aspects of the likelihood of a consumer to operate a quieter unit in an improper location would need to be assessed.

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** The Commission has recently initiated rulemaking concerning improved generator labeling. See 71 Fed. Reg. 50003-7 (August, 24, 2006).

D. Private Sector Consortium for Development of Technological Solutions

A collaborative effort among manufacturers to develop effective technology that addresses a particular hazard is a strategy that has worked in the past with other products. Collaboration among market participants may provide resources beyond the reach of individual competitors which could allow participating manufacturers to better use existing research and development assets, or may provide incentives for them to make product enhancing investments that would not occur absent the collaboration. The consumer may also benefit in that the collaboration may allow accelerated product development that could result in improved products reaching market more quickly **(TAB V)**. One disadvantage of a consortium is that competitive issues can slow progress if there is not consensus on a technical approach. **(TAB Z, FOUO)**.

E. Information and Education Campaign

Engineering solutions cannot reasonably be expected to reduce the number of deaths and injuries in the very near future. To have a more immediate impact on reducing the number of CO poisonings associated with portable generators, particularly those already in consumers' hands or in retailers' and manufacturers' inventories, staff believes that an extensive information and education (I&E) program is needed.

CPSC has issued numerous press releases and safety alerts; produced video news releases; received wide television, newspaper, and radio coverage of generator safety issues; distributed safety information at professional conferences attended by first responders, federal, state, and local health and safety professionals, and public and private sector safety organizations; and coordinated with the American Red Cross and the U.S. Fire Administration in the development of their portable generator safety fact sheets **(TAB W)**. Prior to the 2006 hurricane season, then-Chairman Stratton held a press event and recorded a video news release on this topic. Prior to the 2005 hurricane season, CPSC field staff arranged for the distribution of CPSC's portable generator safety alert at the National Hurricane Conference exhibition held in New Orleans. During the 2005 hurricane season, the staff partnered with CDC, the American Red Cross, first responders, and others to create posters and doorhangers concerning the CO hazard associated with generators and to distribute them to homeowners in disaster-affected areas.

In the aftermath of Hurricane Katrina, the staff also engaged in efforts to work with generator retailers in the disaster-affected areas, providing them with safety information to be posted at point-of-sale and on generators to inform potential first-time generator users and others of the CO hazard. Based on CPSC staff observations, there was very limited follow-through by the retailers. Staff believes a stronger commitment from them is needed to increase public awareness of the CO hazard associated with portable generators to a nationwide, year-round effort. Staff believes that safety information should be clearly and consistently displayed in retail outlets where a portable generator can be purchased, and that other products that can help encourage safe generator use (i.e., CO alarms, heavy-duty extension cords, and chains and locks to prevent theft) should be made available for sale in close proximity to the generators themselves. Staff also believes that retailers should provide training for employees as well as customers on safe generator use.

Although CO poisoning deaths and injuries are predictable in that they regularly occur following severe weather events that typically cause power outages, CO poisoning deaths and injuries also occur consistently throughout the year for reasons unrelated to weather-induced power outages. Staff believes that a national education program is needed to address the on-going aspect of the serious CO poisoning hazard associated with generators in particular and with other consumer combustion products in general. A coordinated program involving government, industry, and private sector public safety organizations, such as the American Red Cross, National Fire Protection Association, National SAFE KIDS Campaign, and Home Safety Council, is needed to address this hazard. These national groups focus on safety education delivered at the community level where consumer behavior is most effectively influenced. An example of an education component of a comprehensive consumer safety awareness campaign is provided in **TAB X**.

## IX. Cost Estimates of Intervention Strategies

Staff has attempted to estimate the costs of the various intervention strategies. Based on responses to the RFI, the cost increase to produce generators with engines with substantially reduced CO emissions is indicated to be on the order of $40 to $200. However, as noted above, with the proposed CARB and intending-to-be proposed EPA regulations for small engines, staff believes the incremental cost increase for targeting CO emissions reductions on generator engines that will have catalytic converters to meet those requirements may be less than that cost range. For the remote CO detection automatic shut off device, staff estimates that a production unit could add an additional $100 to the cost of a portable generator. Staff estimate for features that could deter theft are on the order of $20. Staff does not have an estimate for features that would reduce engine noise..

The information and education safety campaign noted in **TAB X** was conducted from 1994 to 1999 at a cost to manufacturers of approximately $15 million. Staff believes that this cost, adjusted for inflation, can serve as the starting point of a cost estimate for a similar effort to educate about the CO hazard associated with portable generators.

The cost increase associated with incorporating weatherization features (raintight or rainproof enclosure, in-use weatherproof receptacle covers, and ground fault protection for all receptacles, as a minimum) to a generator is difficult to estimate. The cost to produce a raintight or weatherproof enclosure will vary greatly due to the wide variation in current product designs, which range anywhere from small encased units that are easily hand-transportable to much larger frame-mounted open construction units. This wide range of product designs translates to a wide range of required product modifications that will in turn necessitate varying degrees of manufacturing re-tooling and component testing, as a minimum, in order to meet raintight or weatherproof requirements.

Staff conducted a limited survey of commercially-available components to estimate the cost of ground fault protection for portable generators. The search found 120-volt receptacle-mounted units priced under $10. No two-pole, 120/240 V receptacle GFCI exists so off-the-shelf protection for 120/240 V receptacles would be provided by a GFCI circuit breakers. 120/240 V GFCI circuit breakers intended for installation in a panelboard were list-priced by manufacturers' catalogs in the range of $300 but were available at a much lower retail cost in the range of $100. These units may need modification in order to be mounted on a generator and perform properly when subjected to engine vibration, heat, and outdoor conditions. It should be noted that some models of portable generators with GFCI protection are currently available on the consumer market.

Because of these factors, staff does not have an estimate for the cost increase to add weatherization features at this time. Also, staff does not have an estimate of the cost increase associated with engine modifications that may be necessary to address the ability of engines to operate in cold, damp weather conditions that cause icing and hamper engine operation.

## X. Voluntary Standards, Staff's Assessment, and OSHA Regulations Concerning Portable Generators

Staff reviewed existing voluntary standards to determine the extent to which they may address CO poisoning hazards associated with generators. There is an existing applicable international standard, published by the International Organization for Standardization, ISO 8528-8:1995(E) *Reciprocating internal combustion engine driven alternating current generating sets – Part 8: Requirements and tests for low-power generating sets*, and an existing applicable Canadian standard, published by the Canadian Standards Association, C22.2 No. 100-04 *Motors and Generators* (relevant details of these standards are presented below). At the present time, there is no U.S. voluntary safety standard for portable generators. Underwriters Laboratories (UL) is in the process of developing the first edition of UL 2201 *Portable Engine-Generator Assemblies*, through an ANSI-accredited committee process using a Standards Technical Panel (STP). CPSC staff is a non-voting member of the STP.

A. UL 2201 "*Portable Engine-Generator Assemblies,*" draft proposed first edition

Since February 2003, the STP has developed four draft versions of the proposed standard. With each draft, CPSC staff has submitted comments and recommendations to the UL 2201 STP secretary. CPSC staff has commented that the draft proposed standard does not adequately address hazards to consumers and has recommended the following for inclusion in the proposed standard:

- Performance requirements to address consumer exposure to unsafe CO emissions.
- Performance requirements that would permit safe outdoor use of generators in rain or other poor weather conditions and could potentially eliminate conflicting hazard avoidance warnings concerning the CO poisoning and electrocution hazards.
- Improvements to the labeling, markings and instructions for portable generators to adequately warn consumers of the CO hazard and inform them of appropriate safety measures.
- Requirements for tests to verify generator operability when used in cold, damp weather that causes icing.

In December 2004, UL made formal disposition that the proposed standard would move forward without performance requirements to address CO emissions or weatherization or testing requirements for cold weather operation. The draft proposed standard does have "optional" requirements for units that can be marketed as rainproof or raintight; however, staff is not aware of any currently available portable generators that would be certified to these optional requirements. The draft proposed standard addresses the CO poisoning hazard solely through requirements for cautionary markings and instruction manuals.

In May 2005, UL's Consumer Advisory Council formed an ad hoc group to review the issues relevant to the CO hazard associated with portable generators with the goal of potentially providing advice, guidance, or recommendations in an advisory capacity to the STP or UL management. UL is waiting to release the fifth draft version of the standard to the ad hoc group until STP consensus has been reached on issues that remain unresolved in the proposed standard since the last STP meeting on May 4, 2005. As of this writing, staff is not aware of any STP activity currently on-going.

Because UL recognized that it may take some time for the STP to achieve consensus on the draft proposed standard, UL decided in December 2005 to take steps toward issuing an Outline of Investigation for portable generators. As UL has explained, an "Outline of Investigation serves as the requirements with which a product must conform in order to be eligible to bear the UL Listing Mark. Although such Outlines of Investigation are not consensus standards, they represent UL's judgment, together with due consideration of public comments." [26] UL states that it is their intention that, at a later date, the draft proposed standard will be adopted as an ANSI standard upon consensus within the STP.

In January 2006, UL provided staff with a draft of the Outline of Investigation that was being prepared as UL's requirements for portable generators and requested staff's comments on it. The Outline, as drafted, included requirements for cautionary markings and advisory information as well as features that will facilitate safe use in rain (rainproof enclosure, raintight while-in-use receptacle covers, and ground fault circuit interrupters (GFCIs) on all alternating current output circuits). It also included optional weatherproof requirements for units intended to be sold as safe for continual storage, as opposed to just use, outdoors. As stated by UL, they are "very much interested in working with CPSC in the development and promulgation of this Outline of Investigation, to assure that it fulfills, to the greatest possible extent, CPSC's objectives in mitigating CO hazards." [26]

After reviewing the draft Outline of Investigation, staff prepared recommendations for UL to consider for incorporation into the document. Recognizing that manufacturers are not likely to voluntarily adopt performance requirements to address consumer exposure to unsafe CO emissions, staff's recommendations were, in large part, confined to the requirements for cautionary markings and instruction manuals (**TAB Y**). Staff's recommended CO warning label and the rationale supporting it are also provided in **TAB Y**. UL incorporated staff's recommendations and issued the Outline of Investigation, *Subject 2201 Outline of Investigation for Portable Engine-Generator Assemblies*, on April 7, 2006.

B. International Organization for Standardization ISO 8528-8:1995(E)

ISO 8528-8:1995(E) *Reciprocating internal combustion engine driven alternating current generating sets – Part 8: Requirements and tests for low-power generating sets* is a standard applicable to portable generators sold overseas. Similar to the proposed UL 2201, its requirements regarding the CO poisoning hazard are limited to labels and markings. It requires that the generating set "must have a permanently attached label which instructs the user that exhaust gas is poisonous, do not operate in an unventilated room." And it requires that the general safety information section of the instruction manual shall mention "Engine exhaust gases are toxic. Do not operate the generating set in unventilated rooms. When installed in ventilated rooms, additional requirements for fire and explosion shall be observed." In contrast to the proposed UL 2201, it does have a requirement that the generator be able to start-up and operate at ambient temperatures between -15°C and 40°C (5°F and 104 °F). However, this requirement does not specify the ambient relative humidity that is needed to simulate conditions that induce icing of the carburetor and crankcase breather system. Other critical performance issues pertaining to the CO hazard are not addressed.

C. Canadian Standards Association C22.2 No. 100-04 *Motors and Generators*

C22.2 No. 100-04 *Motors and Generators* is a standard that includes basic requirements for portable and standby generators sold in Canada. This standard does not have any requirements that address the CO poisoning hazard. Also, it does not have any requirements to verify engine operability in cold, damp conditions that would induce icing of the carburetor and crankcase breather system.

D. OSHA Regulations Concerning Portable Generators

The Occupational Safety and Health Administration (OSHA) has regulations[††] that define proper installation and use of portable generators at a temporary construction site or permanent workplace for applications in which cord-and-plug-connected electrical equipment is supplied directly from the generator's receptacles or in instances where the generator supplies a temporary distribution system. Under specific conditions, the requirements for ground-fault protection for personnel are satisfied by GFCI-protected receptacles on the generator.

## XI. Discussion and Staff Recommendations

CO poisoning deaths associated with portable generators continue to occur, predictably and with increasing frequency. They regularly occur following severe weather events that typically cause power outages, such as hurricanes and winter storms, yet there currently is no clear way for portable generators to be used safely either indoors or outdoors in the inclement-weather conditions that frequently precipitate their use. These deaths also occur throughout the year, unrelated to weather-induced power outages and they occur when generators are used indoors as well as outdoors in some cases when the generator is placed near openings to the home. With increasing consumer ownership and use of portable generators, staff believes that more effective intervention is urgently needed to reduce the rising CO death toll associated with consumer use of portable generators.

Staff believes that progress in developing effective voluntary standards is inadequate. As of this writing, the draft proposed standard UL 2201 and standard ISO 8528-8:1995(E) address the

[††] 29 C.F.R. § 1926.404(b)(1)(ii) and 29 C.F.R. § 1926.404(f)(3)(i).

hazard through warnings and markings requirements. CSA C22.2 No. 100-04 does not address the CO hazard at all. UL's Outline of Investigation, which is not a voluntary standard, does include requirements for CO warnings and features that will permit safe use in rain, but it does not have performance requirements that address consumer exposure to unsafe CO emissions or test requirements to verify the engine's ability to operate in icing conditions.

Mandatory generator performance requirements could be considered to protect consumers against the hazard of acute residential CO exposures that can result in death or in serious and/or lasting adverse health effects in exposed individuals. Respondents to the RFI assert that there are technical solutions that could achieve this. Representatives of the generator industry have stated that solutions will be challenging and costly to develop. In addition, staff believes that requirements for weatherization of portable generators could also be considered as a potential means to reduce the CO hazard if the conflicting hazard avoidance instructions regarding the electrocution hazard relative to the CO hazard can be eliminated. Furthermore, staff believes that test requirements to verify the engine's ability to operate in cold, damp weather that causes icing could be considered. Staff also believes that features that could deter generator theft and reduce the engine noise could be considered. Formation of a private sector consortium to develop all of these requirements may be an option.

While technical solutions are examined, a national education program could also be considered to address the on-going aspect of the serious CO poisoning hazard associated with generators. A formalized commitment with retailers for a nationwide, year-round effort to provide safety information, co-location of associated products to enhance safe generator use, and customer and employee training could also be considered.

In summary, staff recommends that the Commission initiate rulemaking to pursue additional regulatory options by publishing an advance notice of proposed rulemaking (ANPR) for public comment. The ANPR should address rulemaking (including establishing mandatory generator performance standards) as well as non-regulatory options such as information and education campaigns, a private sector consortium, and any other potential approach available to the Commission.

## XII. References


1. Ascone, Debra, et al., *Non-Fire Carbon Monoxide Deaths Associated with the Use of Consumer Products, 2002 Annual Estimates*, U.S. Consumer Product Safety Commission, Washington, D.C., July 12, 2005.

2. Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-457 A-G of the 2001 Residential Energy Consumption Survey.

3. Vagts, Susan, *Estimating Non-Fatal Carbon Monoxide Poisoning Injuries*, CPSC Memorandum to Donald Switzer, Program Leader of Fire/Gas Codes & Standards, U.S. Consumer Product Safety Commission, Washington, D.C., November 27, 2002.

4. U.S. Environmental Protection Agency, *Air Quality Criteria for Carbon Monoxide*, EPA 600/P-99/001F, (http://www.epa.gov/NCEA/pdfs/coaqcd.pdf), June 2000.

5. Data from Synovate, Inc.

6. Data from Multi-Client Research Group, Synovate, Inc.

7. Earnest, G.S., *Carbon Monoxide Poisonings from Small, Gasoline-Powered, Internal Combustion Engines: Just What is a "Well-Ventilated Area"?*, American Industrial Hygiene Association Journal, November 1997.

8. Houck, et al., *Epidemic Carbon Monoxide Poisoning Following a Winter Storm*, Journal of Emergency Medicine, Vol. 15, No.4., 1997.

9. Hampson, et al., *Unintentional Carbon Monoxide Poisoning Following a Winter Storm*, MMWR, Vol.42, No.6, February 19, 1993.

10. Wrenn, et al., *Carbon Monoxide Poisoning During Ice Storms: A Tale of Two Cities*, Journal of Emergency Medicine, Vol. 15, No.4., 1997.

11. Daley, et al., *An Outbreak of Carbon Monoxide Poisoning After a Major Ice Storm in Maine*, Journal of Emergency Medicine, Vol. 18, No.1., 2000.

12. Holt, et al., *Community Needs Assessment and Morbidity Surveillance Following an Ice Storm - Maine, January 1998*, MMWR, Vol. 47, No.17, May 8, 1998.

13. Colorado Department of Public Health and Environment, *News Release: Generators Can Be Deadly If Not Vented Properly*, December 17, 1999.

14. Lavonas, et al., *Use of Carbon Monoxide Alarms to Prevent Poisonings During a Power Outage - North Carolina, December 2002*, MMWR, Vol. 53, No.9, March 12, 2004.

15. CDC, *Carbon Monoxide Poisonings from Hurricane-Associated Use of Portable Generators—Florida, 2004*, MMWR 2005;54:697-700.

16. CDC, *Epidemiologic Assessment of the Impact of Four Hurricanes – Florida, 2004*, MMWR 2005;54:693-697.

17. CDC, *Carbon Monoxide Poisoning After Hurricane Katrina --- Alabama, Louisiana, and Mississippi, August – September 2005*, MMWR 2005;54(Early Release):1-3.

18. U.S. EPA, Office of Mobile Sources, *Milestones in Auto Emissions Control*, Fact Sheet OMS-12, August 1994.

19. Mott, Joshua A., et al., *National Vehicle Emissions Policies and Practices and Declining US Carbon Monoxide-Related Mortality*, Journal of the American Medical Association, Vol. 288, No. 8: 988-995, August 28, 2002.

20. U.S. Department of Interior website http://safetynet.smis.doi.gov/COhouseboats.htm referencing numerous documents.

21. Zimmer, Anthony, et al., *An Evaluation of Catalytic Emission Controls and Vertical Exhaust Stacks to Prevent Carbon Monoxide Poisonings from Houseboat Generator Exhaust*, Report No. EPHB 171-36a, U.S. Department of Health and Human Services, September 2005.

22. Coultas, David, et al., *New, Highly Durable, Low PGM Motorcycle Catalyst Formulations for the Indian 2-Wheeler Market*, SAE Paper No. 2003-26-0003.

23. Akamatsu, Shunji, et al., *Research into New Emission Control Techniques for Motorcycles to Achieve the EURO-3 Regulation*, SAE Paper No. 2004-32-0032 / 20044319.

24. Manufactures of Emission Control Association, *Emission Control of Two- and Three-Wheel Vehicles*, May 7, 1999.

25. CDC, *Carbon Monoxide Poisoning After Two Major Hurricanes --- Alabama and Texas, August – October 2005*, MMWR March 10, 2006;55(09);236-239.

26. E-mail communication dated December 21, 2005 between Hugh McLaurin, CPSC, and Jim Beyreis, UL.

# TAB A

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

**Memorandum**

Date: October 12, 2005

TO : Patricia Semple, Executive Director

FROM : Hal Stratton, Chairman

SUBJECT : Review of Portable Generator Safety

In light of carbon monoxide (CO) deaths and injuries attributable to the consumer use of portable generators, I direct the staff to undertake a thorough review of the status of portable generator safety. The staff's review should address the following issues at a minimum:

1. Feasibility of safety cut-offs that would shut down a generator before CO reaches unsafe levels;
2. Sufficiency of warning labels to address the danger of CO poisoning associated with portable generators used within or near residences;
3. Development of portable generator performance requirements that would substantially reduce CO emissions;
4. Feasibility of weatherization of portable generators (including ground fault circuit interrupter (GFCI) protection) for use in wet and/or cold outdoor environments;
5. Creation of an information and education campaign, including partnering with other federal agencies (including but not limited to the Centers for Disease Control and Prevention (CDC), the National Institute for Occupational Safety and Health (NIOSH), and the National Oceanic Atmospheric Administration (NOAA)), and private sector (American Red Cross, retail/hardware trade associations) to spread message through various media;
6. Potential benefits of the creation of a private sector consortium made up of generator manufacturers that would cooperatively develop a technical solution that adequately addresses the current CO poisoning hazard.

This review should include not only an assessment of the existing voluntary standards and industry practices with regard to safe generator use, but also an exhaustive summary of other potential methods for improving portable generator safety. Additionally, CPSC staff is to continue to monitor the on-going efforts to address this issue within the voluntary standards arena.

The staff should report the results of their comprehensive review to the Commission as soon as is feasible. It would be my intent that this review be given priority in the staff and Commission's agenda.

# TAB B

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

**Memorandum**

Date: August 24, 2006

TO : Janet Buyer, Project Manager, ESFS

THROUGH : Gregory B. Rodgers, Ph.D., AED, EC GBR
Deborah V. Aiken, Ph.D., Senior Staff Coordinator, EC DVA

FROM : Charles L. Smith, EC CLS

SUBJECT : Portable Electric Generator Sets for Consumer Use: Additional Data on Annual Sales, Number in Use, and Societal Costs[1]

## Introduction

Previous estimates of the number of portable electric generator sets in consumer use provided by the Directorate for Economic Analysis (EC) ranged from 1.1 to 1.4 million units in 2003.[2] These estimates were based on data published in a report by the market research firm, Frost & Sullivan.[3] That data indicated that generator sales to U.S. consumers were 418,000 units in 1999; 164,000 in 2000; 195,000 in 2001, and 203,000 in 2002. The CPSC's Product Population Model was used to estimate the total number of portable generators in household use based on estimated historical sales and different assumptions regarding average product life. Recently EC purchased access to sales and saturation levels for a wide range of consumer products from the market research firm, Synovate, Inc. Among the data available from Synovate are consumer survey data for sales and ownership of generators. A review of these data indicates that sales and ownership of portable generators are higher than previously estimated from the Frost & Sullivan report.

## Consumer Survey Data on Ownership of Generators

Synovate reports data on household product saturation trends for generators and other products. Table 1 presents estimates of generators in use based on Synovate saturation estimates and other product information provided by Synovate consumer purchase surveys. As shown in the table, the estimated percentage of households owning generators from January 2002 through January 2005 ranged from 8 to 9 percent. Given Bureau of the Census estimates of U.S.

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[1] This memorandum reflects the analysis of CPSC staff, has not been reviewed or approved by, and may not necessarily reflect the views of the Commission.

[2] Donaldson, Mary F. *Portable Generators.* Memorandum to Janet Buyer, Project Manager, ESFS. August 22, 2005.

[3] Frost & Sullivan. *North American Portable Power Markets.* September 26, 2003.

households from 2002-2005[4], 8.8 to 10.2 million households are estimated to have owned generators annually during this period. Synovate ownership data show an average of 1.12 generators being owned by households that have generators. Therefore, the total estimated number of generators in household use ranged from about 9.9 million in 2002 to 11.4 million in 2005. Synovate data from consumer purchase surveys indicate that about 93 percent of generators purchased by consumers in recent years have been portable, and about 7 percent have been fixed units. If we assume that this proportion also applies to ownership of units, the estimated number of portable generators in household use ranged from about 9.2 million units in 2002 to 10.6 million units in 2005.

**Recent Sales Data**

Synovate provided estimates of 2003-2005 generator purchases by consumers based on data from its Multi-Client Research Group (SMRG) sample. Estimated retail sales of generators to consumers totaled 1,243,787 units in 2003; 1,595,930 units in 2004 and 1,236,934 units in 2005. Based on Synovate consumer survey data on the proportion of consumer generators purchased that were portable vs. fixed units, an estimated 1.1 million portable generators were purchased by consumers in 2003, 1.5 million were purchased in 2004, and 1.1 million were purchased in 2005. Synovate attributed higher generator sales in 2004 to the large number of residential electric customers in Florida and other coastal states that faced power outages as a result of hurricane damage that year. Although extensive hurricane damage also occurred in Gulf states in 2005, Synovate's assessment of the overall generator demand for the year was that it was depressed due to high sales in 2004, a greater affected population base in Florida than in Louisiana (the state hardest hit by 2005 hurricanes), and the extensive long-term evacuation of residents associated with the 2005 hurricanes.[5]

Based on responses of consumers who named the brand of portable generator they purchased during 2003-2005, the leading brands were Coleman (22.1%), Honda (20.8%), Sears/Craftsman (12%), Troy-Bilt (11%), and Generac (11%). These brands combined for about 77 percent of the market for portable generators during 2003-2005.[6] The leading supplier of engines for portable generators based on surveyed consumers who provided the information was Briggs & Stratton (51.4%), followed by Honda (25.1%), Tecumseh (6.3%), Kohler (2.1%), Kawasaki (1.2%), and Onan (1.2%).

Previous estimates of portable generator sales indicated that the peak year for consumer sales occurred in 1999. As previously noted, based on information provided in the Frost & Sullivan report, EC staff estimated U.S. sales of portable generators to consumers to have totaled 418,000 units in that year, largely attributable to fears over power outages that might result from "Y2K" problems. Sales were estimated to be much lower in 2000-2002 (164,000 units to 203,000 units). The estimates of annual sales of one million or more units in recent years were supported by statements made by major generator manufacturers in meetings with CPSC staff (which prompted the purchase of the Synovate data). Although at this time we have only

[4] U.S. Census Bureau, *Current Population Survey, 2002-2005 Annual Social and Economic Supplements.*
[5] Wilson, Kaye. Consumer & Business Insights Division, Multi-Client Research Group, Synovate, Inc. e-mail to Charles L. Smith, Directorate for Economic Analysis, CPSC. August 1, 2006.
[6] Data from Synovate's Continuing Consumer Survey.

received estimated unit sales for 2003 through 2005 from Synovate, its historical trend data for saturation levels indicate that consumer purchases in years prior to 2003 were higher than indicated by other information that was available to EC staff.

**Product Characteristics of Portable Generators Sold in Recent Years**

Synovate's Continuing Consumer Survey provides information on the characteristics of portable generators purchased by consumers. Table 2 shows the distribution of portable generator sales for 2003 through 2005 by watts of electrical output. According to the survey data, 56 percent of portable generators sold to consumers during 2003-2005 had electrical outputs ranging from 3,500 watts to 6,499 watts. About 23 percent of units sold had outputs of less than 3,500 watts and about 21 percent had outputs of 6,500 watts or more.[7]

Nearly all (98.7%) portable generators sold in 2003-2005 were fueled by gasoline, according to responses to Synovate survey data. Generators that were fixed in place were less likely to be fueled by gasoline. About 60 percent of these units purchased during 2003-2005 were fueled by either natural gas or LP gas, according to the survey.

**Societal Costs of Generator-Related Carbon Monoxide Deaths**

Over the four-year period of 2002-2005 the number of deaths caused by carbon monoxide (CO) from generators that were reported to the CPSC averaged about 51 annually.[8] Average annual societal costs of these CO deaths are estimated to be about $256 million.[9] During the 2002-2005 period, an annual average of about 10.4 million generators (portable and fixed units) were owned by households, based on Synovate data discussed above. Therefore, average annual societal costs related to CO poisoning deaths reported to the CPSC associated with generators was $24.56 per generator. These average annual societal costs could be expected for each year that a generator remains in use. The expected useful life of generators largely depends on hours of use. Generators purchased for household backup power usually remain operational for 5 to 7 years according to sources previously cited by EC.[10] Based on a 7-year expected product life, the present value of expected societal costs of CO poisoning deaths from the use of generators is estimated to be about $157 per generator.[11] Since these costs are based on death reports received by the CPSC, actual societal costs are higher, to the extent that incidents do not come to the attention of the CPSC.

The benefits associated with safety interventions would depend on the effectiveness of those measures. For every 10 percent reduction in the hazard resulting from an intervention, benefits of almost $16 per generator would be expected. For example, an intervention that is 50 percent effective would result in estimated benefits of about $79 per generator and an

[7] Data from Synovate's Continuing Consumer Survey.
[8] Hnatov, Matthew V. "Non-fire Carbon Monoxide Fatalities Associated with Engine-Driven Generators and Other Engine-Driven Tools in 2002 Through 2005." Memorandum to Janet Buyer, Project Manager, ESFS. August 16, 2006.
[9] Based on a $5 million value of a statistical life.
[10] Donaldson, Mary F. *op. cit.*
[11] Expected future societal costs are discounted by 3% annually to express them in their present value.

intervention that is 75 percent effective would have expected benefits of about $118 per generator.

These estimated societal costs related to CO deaths and the estimated potential benefits of reducing these deaths are based on death counts that do not separate incidents involving portable generators from those involving fixed-position generator units. If portable generators present different levels of risk of CO poisoning than fixed units, the expected costs and potential benefits could be greater or lower than the estimated averages for all generators.

The CPSC does not publish CO injury estimates because it is not possible to make distinctions among CO emergency room visits based on severity due to the lack of the necessary detail available in individual NEISS records. However, individuals who survive serious prolonged exposure to CO from portable generators can have serious long-term health consequences.[12] Thus, beyond the estimated costs related to CO poisoning deaths, additional societal costs from non-fatal CO poisoning would increase the overall societal costs that might be addressable by interventions, with corresponding additional expected benefits.

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[12] U.S. Environmental Protection Agency, *Air quality Criteria for Carbon Monoxide*, EPA 600/P-99/001F, (http://www.epa.gov/NCEA/pdfs/coaqcd.pdf), June 2000.

# Table 1.
# Estimated Household Ownership of Generators

| | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|
| Generator Household Saturation (%) | 8.05 | 8.36 | 8.01 | 9.00 |
| Households | 109,297,000 | 111,278,000 | 112,000,000 | 113,146,000 |
| Households with Generators | 8,798,409 | 9,302,841 | 8,971,200 | 10,183,140 |
| Generators per Household | 1.12 | 1.12 | 1.12 | 1.12 |
| Total Estimated Number of Generators in Use | 9,854,218 | 10,419,182 | 10,047,744 | 11,405,117 |
| % of Generators that were Portable | 93.0% | 93.0% | 93.0% | 93.0% |
| Estimated Number of Portable Generators in Household Use | 9,164,422 | 9,689,839 | 9,344,402 | 10,606,759 |

Note: Estimates are for January of each year.

Sources: Synovate, Inc. (Ownership, percent portable, units per household); Bureau of the Census (households).

## Table 2.
## Consumer Purchases of Portable Generators, by Watts of Output, 2003 - 2005

| | Percent of Units, by Year Purchased | | | |
|---|---|---|---|---|
| Watts | 2003 | 2004 | 2005 | 2003 - 2005 |
| Under 2,000 | 13.2 | 10.0 | 8.2 | 10.5 |
| 2,000 to 3,499 | 15.6 | 13.0 | 9.5 | 12.8 |
| 3,500 to 4,999 | 14.1 | 17.2 | 17.7 | 16.4 |
| 5,000 to 6,499 | 38.9 | 37.9 | 42.5 | 39.6 |
| 6,500 to 7,999 | 10.3 | 12.9 | 13.3 | 12.2 |
| 8,000 to 9,999 | 2.8 | 4.1 | 4.8 | 3.9 |
| 10,000 to 14,999 | 3.8 | 2.6 | 2.2 | 2.9 |
| 15,000 to 19,999 | 0.7 | 1.5 | 1.2 | 1.1 |
| 20,000 and over | 0.6 | 0.8 | 0.5 | 0.6 |
| All Units | 100.0 | 100.0 | 100.0 | 100.0 |

**Source: Synovate Continuing Consumer Survey**

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

**Memorandum**

Date: August 22, 2005

TO : Janet Buyer, ESFS

THROUGH: Gregory B. Rodgers, Ph.D., AED, EC GBR

Deborah V. Aiken, Ph.D., Senior Staff Coordinator, EC

FROM : Mary F. Donaldson, EC

SUBJECT : Portable Generators

Introduction

This report presents an overview of the market for portable generators and includes information about manufacturers, production, units in use and types of generators preferred by consumers.[1]

The Electric Power Research Institute (EPRI) breaks down portable generators into the following components which are mounted onto a metal chassis (1):

- internal combustion engine,
- AC alternator,
- starting and regulating controls,
- electric power outlets,
- safety devices such as ground fault circuit interrupters and circuit breakers,
- starter.

Generators may be categorized by power output. Small generators produce 3.0 to 4 kilowatts (kW); mid-sized units, 4.5 to 7 kW; and large units around 10kW (8). Both commercial users and consumers purchase generators. While the markets are not clearly differentiated, consumers overwhelmingly purchase light duty lower cost models.

Portable generators run on gasoline, diesel, natural gas, or liquid propane (LP). A few models use multiple fuel sources (8). Consumers generally purchase gasoline-powered units. A market study report by Frost & Sullivan indicated that only 2 percent of light duty portable generators run on fuels other than gasoline (12).

[1] It should be noted that this memo reflects the analysis of CPSC staff, has not been reviewed or approved by, and may not necessarily reflect the views of the Commission.

Portable generators sold in the U.S. produce 60 Hz current. The production of 60 Hz power requires generators to operate at 1800 revolutions per minute (rpm) or multiples thereof. Portable, light duty generators are often powered by 3600 rpm, air-cooled, twin cylinder lawn mower engines (2). These high rpm air-cooled engines have relatively short product lives, providing about 500 hours of use. When used for emergency backup purposes, these light duty units usually remain operational for about 5 to 7 years (1, 12). Units designed for longer service include liquid-cooled 1800 rpm gasoline generators that may provide up to 10,000 operating hours. Similar diesel powered units may provide 30,000 hours of use (2). However, because of their price, longer service units typically are not purchased by consumers.

## Suppliers and Shipments

Generator suppliers are part of the non-road engine and equipment industry. The companies in this market are foreign, domestic, multi-national, and joint ventures, and include both small and large businesses (5). Most generator suppliers are equipment assemblers, i.e., they assemble purchased components to produce a generator set. The largest suppliers of generators also manufacture their own engines.

In the course of this study, we identified more than 40 U.S. suppliers of portable generators in the under 15 kW output range – the range most commonly used by consumers. These firms are listed in Table 1 at the end of this report, along with the electrical output ratings and price ranges, where known. Most firms identified sell their generators nationwide. However, Frost and Sullivan indicated that there are some small assemblers that operate in regional markets (12). Three firms dominate the national market – Briggs and Stratton (27 percent), Coleman (18 percent), and Honda (13 percent) – producing about 60 percent of generator sales revenues in 2002 (11, 12).

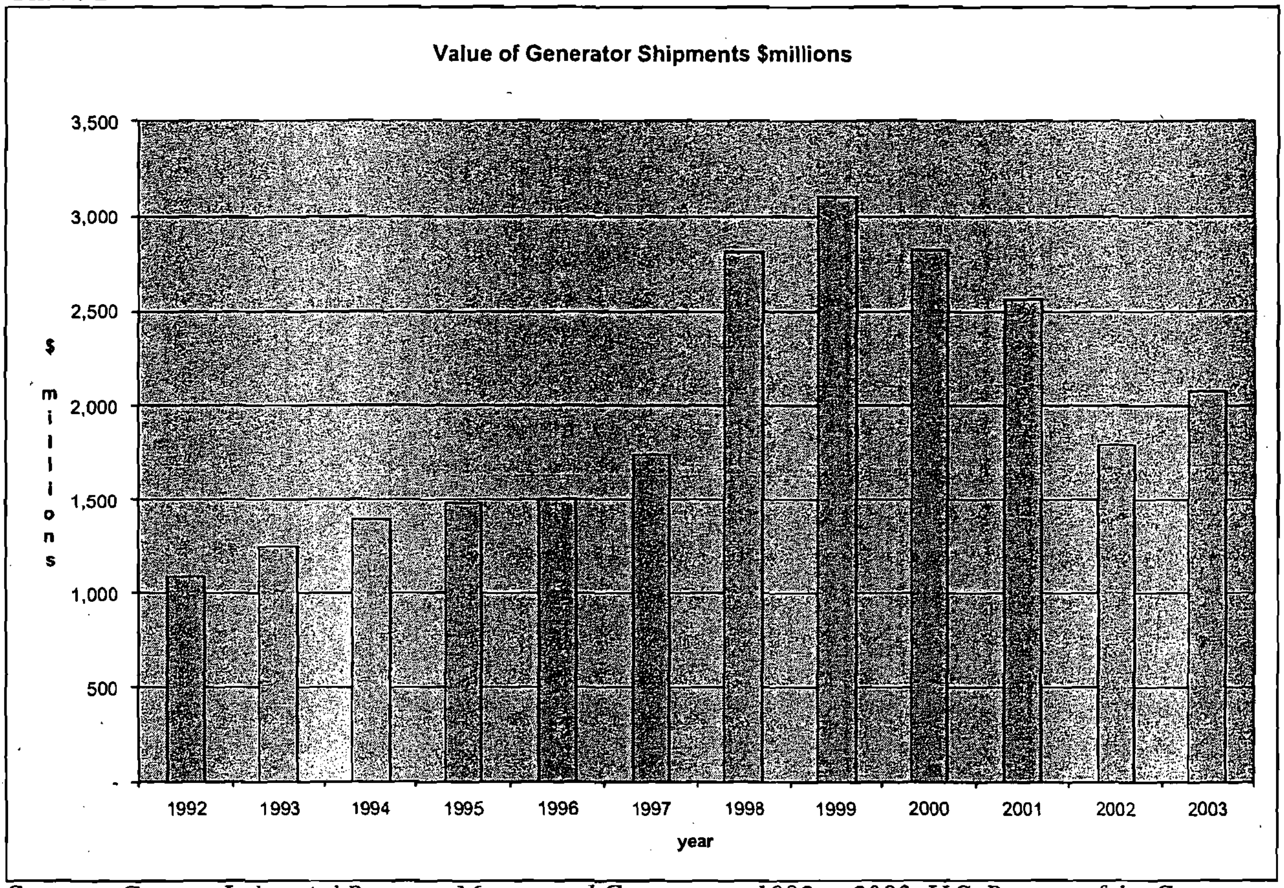
More than half of portable generators are sold through standard mass market retail channels. This includes hardware stores, discount retailers and home centers. Equipment dealerships having exclusive relationships with manufacturers account for about one quarter of sales. Direct and internet sales account for the remainder (12). Generators are also rented from equipment rental companies.

The U.S. Bureau of the Census reports generator shipments in terms of shipment valuation and units, categorized by power output and engine fuel type. Due to disclosure restrictions, no data was reported in the specific subcategory of interest in this report: gasoline-powered generators under 15 kW output. Complete "value of shipment" data is available for combined categories of generators, including portable and fixed generators, with power output ranging from below 5kW to over 100kW. Chart 1 shows this information graphically. As can be seen in the chart, 1999 was a peak year for generator shipments. This can be attributed to demand fueled by concerns about power grid failure and infrastructure sabotage leading up to the Year 2000 (1, 3, 13). In 2003, manufacturers shipped about $2 billion worth (FOB plant[1]) of

[1] FOB means free-on-board. FOB plant is the price paid for goods at the factory loading dock and does not include transportation charges.

gasoline and diesel driven generator sets. It should be noted that most of these shipments were of commercial and industrial generators.

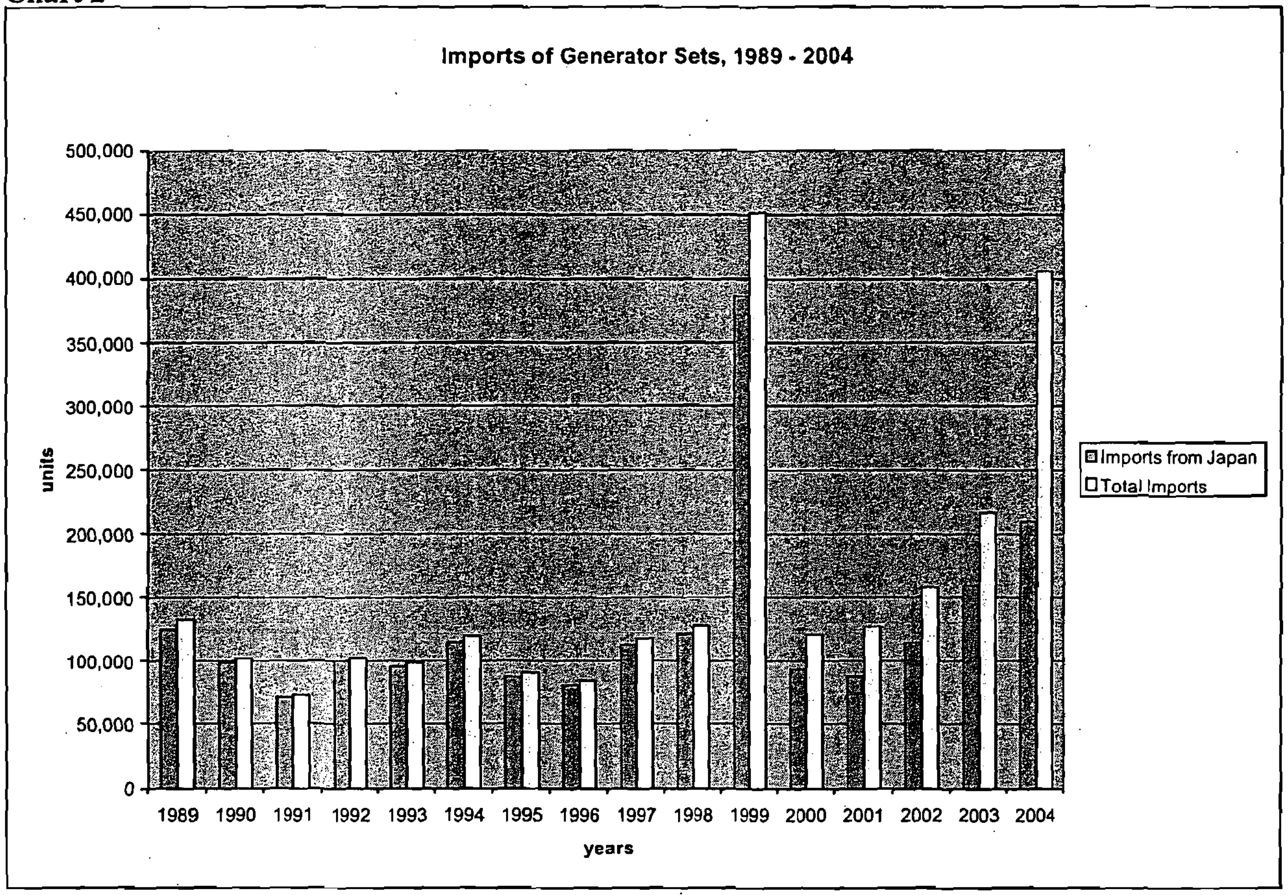
**Chart 1**




*Source: Current Industrial Reports: Motors and Generators: 1992 to 2003, U.S. Bureau of the Census.*

Imports of generator sets are illustrated in Chart 2. About 406,000 generator sets were imported in 2004 with a customs value of around $400 million. The majority (77.5 percent) of imports were gasoline powered generators with a rated capacity of less than 5 kW output. Imports from Japan constitute the largest percentage of imports of generator sets of all sizes. In 2004, Japanese imports rose, but fell as a percentage of imports from almost three quarters of imports to close to half, with imports from China surging 450 percent to over 110,000 units or more than 25 percent of units imported.

**Chart 2**




*Source: United States International Trade Commission.*

Exports of generators in 2004 comprised 85,420 units with a FAS[2] value of about $600 million. Most U.S. generator exports were shipped to Canada and Mexico, representing 67 percent of units exported, although just 27 percent of the total FAS value of U.S. exports. Nearly 83 percent of U.S. generator exports, in monetary terms, were for large capacity diesel powered generators. In terms of units exported, 70 percent were small capacity gasoline powered units.

## Trade Associations

Generator manufacturers also produce other types of outdoor equipment such as lawn mowers and other lawn and garden equipment. Many are members of the Outdoor Power Equipment Institute, an association of mostly lawn care equipment manufacturers. There is also the Electrical Generating Systems Association (EGSA), an association of large on-site electrical generator manufacturers. Many EGSA members also manufacture small portable generators. Many engine manufacturers that also produce generators are members of the Engine Manufacturers Association.

[2] Free alongside ship (FAS) value is the value of exports at the U.S. port.

Prices

A review of the marketplace revealed a large price range for portable generators. Prices ranged from as low as $399 for a small 1,000 watt output generator from Troy-Bilt to $4,900 for an 11,000 watt generator from Honda. On a kW-output basis prices ranged from about $100 to as much as $1000 per kW. An article in *Consumer Reports* in November 2003 showed a price range of $400 to $3,000 for consumer-use generators (8). The most popular generator prices are in the $500 to $800 range (13). According to a study by Frost and Sullivan, in 2002, average retail prices of light duty portable units were about $723 with a range of about $500 to $1500 (12).

Sales

Based on the Frost & Sullivan study, about 357,000 light duty portable generators were sold in the U.S. in 2002. Of these, an estimated 57 percent or about 203,000 units (representing about $150 million in retail sales) were purchased for use by homeowners. This is down from the peak year for generator shipments in 1999, when about 733,000 units of light duty generators were shipped in the U.S., with perhaps 418,000 for use by homeowners. Table 2 shows estimates of light duty portable generators sales to homeowners, based on Frost & Sullivan's 57 percent estimated rate of sales to homeowners from 2002 (12).

**Table: 2: Estimated consumer purchases of light duty portable generators, 1999 to 2002**

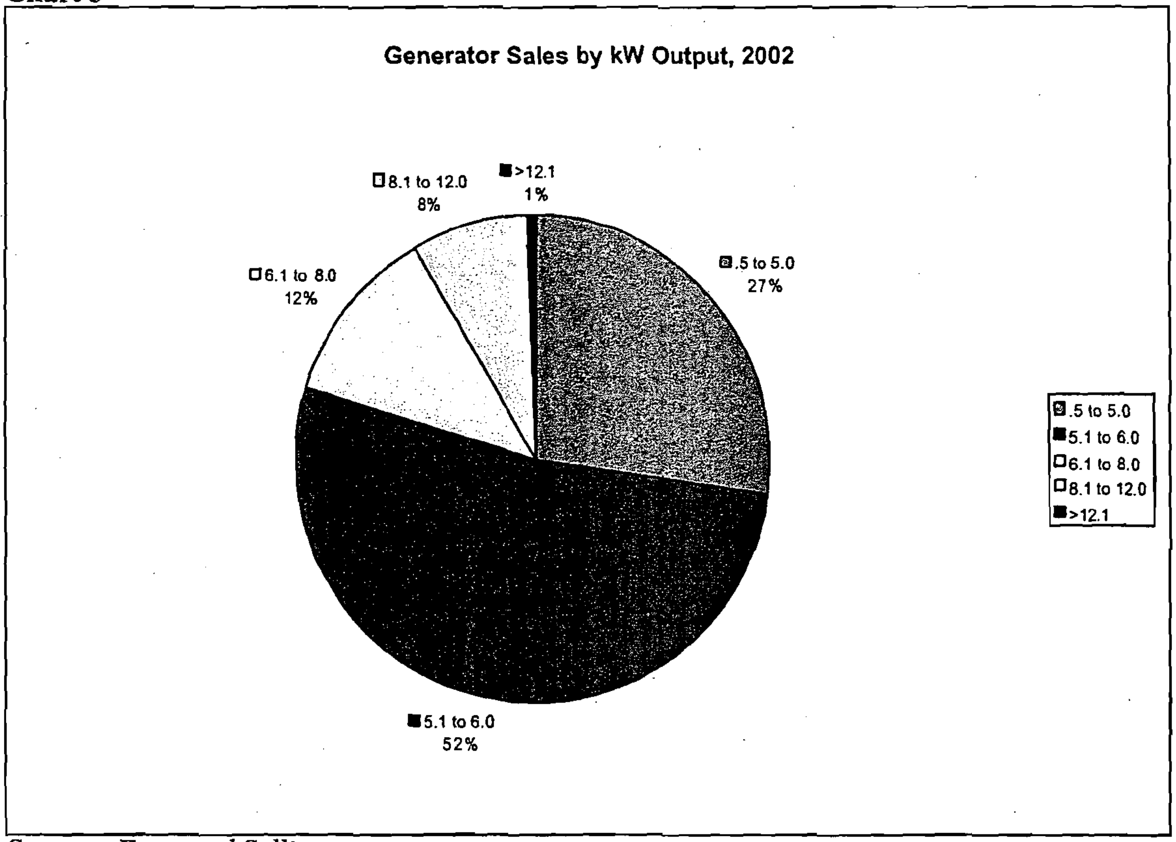
| Year | Total U.S. Sales | Sales to Homeowners |
|---|---|---|
| 1999 | 733,000 | 418,000 |
| 2000 | 288,000 | 164,000 |
| 2001 | 342,000 | 195,000 |
| 2002 | 357,000 | 203,000 |

*Source: Frost & Sullivan*

Consumer demand for generators may be attributed to reactions to events such as power outages caused by weather-related disasters, grid failures, and rolling blackouts as well as fear of outages prompted by security-related concerns (3, 9,12). The large spike in generator sales in 1999 was reportedly a response to fear leading up to the Year 2000 (1, 3, 13). Increased reliance on power for home office functions has also been linked to generator demand (6). Because weather-related events prompt many sales of generators, the summer and fall tropical storm seasons result in the highest unit sales, according to Briggs and Stratton's annual report (11).

According to a study by Frost & Sullivan, homeowners are the largest end users of light duty portable power generators, with the most popular size being 5 to 6kw of output, accounting for about 52 percent of light duty sales. According to EPRI, most residential generators operate in the 3 to 10 kW range (1). Chart 3 below illustrates the breakdown by kW output and percentage of sales.

**Chart 3**




*Source: Frost and Sullivan*

Number in Use

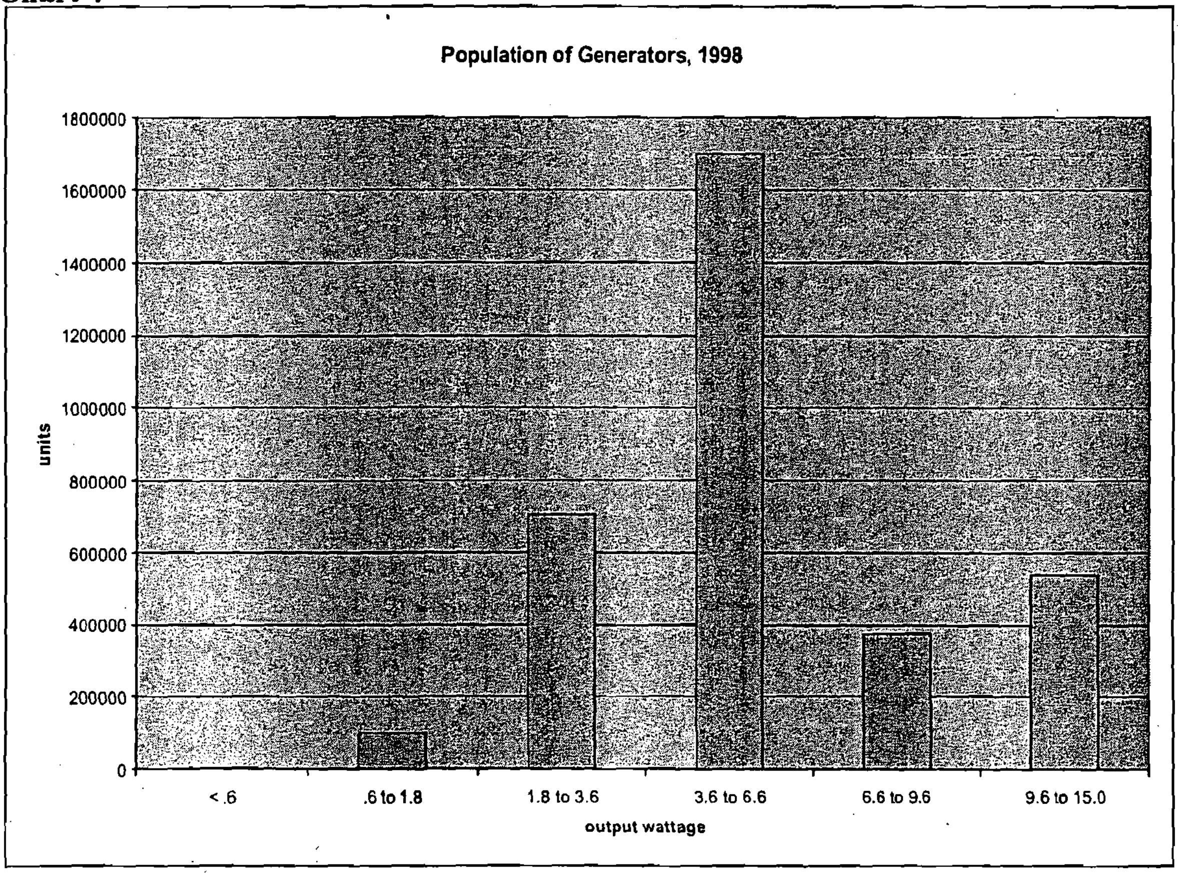
The U.S. Environmental Protection Agency (EPA), in its work on emissions of non-road engines, developed estimates of the population of gasoline powered generators for 1998 for all end users. EPA categorized generators by engine type and horsepower as opposed to kW output. The population of generators in terms of kilowatt output may be roughly estimated by multiplying the horsepower rating by a nominal conversion factor of about 0.6[3]. Table 3 presents the EPA population figures along with this conversion. Chart 4 illustrates the population of generators by power output, converted as described (4).

[3] Because of energy losses, applying the direct conversion of 1 horsepower = .746 kw does not equate to the generator ratings observed in the marketplace, so the conversion of 1 hp = .6 was chosen as more reflective of the marketplace.

**Table 3: Estimated Population of Generators under 25 hp, 1998, all end users**

| Engine Type | 1hp=.6kW | Estimated population, all users | % of generators |
|---|---|---|---|
| 2-stroke, 0-1 hp | 0 to .6 | 4,052 | 0.12 |
| 2-stroke, 1-3 hp | .6 to 1.8 | 100,577 | 2.94 |
| 4-stroke, 3-6 hp | 1.8 to 3.6 | 707,572 | 20.66 |
| 4-stroke, 6-11 hp | 3.6 to 6.6 | 1,699,093 | 49.61 |
| 4-stroke, 11-16 hp | 6.6 to 9.6 | 375,830 | 10.97 |
| 4-stroke, 16-25 hp | 9.6 to 15.0 | 537,782 | 15.70 |
| | | 3,424,906 | 100.00 |

**Chart 4**




Using CPSC's product population model with estimates of historical sales, and assuming an average product life of about 6 years[4], about 1.1 million portable generators were in use in US households in 2003.. If the average product life is as long as 9 years, then the product population model suggests that as many as 1.4 million generators were in use in U.S. households in 2003.

[4] The Frost & Sullivan report indicates that light duty generators last between 5 and 7 years, with an engine design life of around 500 hours (12).

This is less than half of the generators reported by EPA in 1998, suggesting that most of the generators at that time were not being used by consumers.

Using EPA's figures and applying the conversion factor described above, about half of the generators in use under 25 horsepower operate in the 3.6 to 6.6 kW as of 1998. By way of comparison, Frost & Sullivan estimated that about half of the light duty portable generators sold in 2002 were in the 5.1 to 6.0 output range, with 5.5 kW being the most popular size in this range (4, 12).

**Table 1: Manufacturers and Suppliers of Portable Electric Generators***

| Manufacturer/Model | Output Rating | Price Range |
|---|---|---|
| American Honda | .700 to 11kW | $700 to $4,900 |
| Baldor Pow'r Gard Powerchief | 1.3 to 11 kW | $692 to |
| Briggs & Stratton | .9 to 10kW | $450 to $1970 |
| Vanguard Generators (Briggs & Stratton) | 2kw to 10kw | $610 to $2484 |
| Coleman Powermate (Premium, Premium Plus & Professional) | 1.1 to 12kW | $400 to $2150 |
| Craftsman | 3 to 5.6kW | $450 to $750 |
| Deere & Co. (John Deere) | 2.5 to 6.0kW | $800 to $1800 |
| DEK generators | 2 to 6kW | $1,000 to $2,700 |
| DeVilbiss | na | na |
| DeWalt (Black & Decker) | 2.9 to 7kW | na |
| Eastern Tools & Equipment Generators (ETQ) | 2.5 to 6.5KW | $420 to $2800 |
| Generac Portables (Briggs & Stratton) | .9 to 10kW | na |
| Gillette Gen-Pro | 3.0 to 15kW | To $4703 |
| Groban | na | na |
| HawkPower | 1.3 to 6.7kW | $634 to $2460 |
| Husqvarna | 6.55kW | $1300 |
| Ingersoll-Rand | 5.0 to 7.25 kW | na |
| Kawasaki (Powerpartner) | .45 to 6kW | na |
| Kosika generators | na | na |
| Lister-Petter | na | na |
| Mahle, Inc. | na | na |
| Makita | 1.3 to 12 kW | $800 to $3,115 |
| Master | 3.0 to 10kW | $799 to $3,899 |
| Mitsubishi | 1.1 to 6.7 kW | $575 to $2,139 |
| Multiquip (MQ) | 2.2 to 9.7 kW | na |
| NAC | 4.3 to 7.0kW | $1569 to $2300 |
| New Holland North America | na | na |
| Northstar (Northern Tool and Equipment Company) | 2.7 to 15kW | na |
| Onan Portable Generators Sets (Cummins) | 2.5 to 6.0kW | na |
| Porter-Cable (commercial) | 3.5 to 10kW | na |
| Pramac (Power Gard) | 5kw, 7.5kw | $524 to $2500 |
| Robin America (Subaru) | 1.3 kW to 13.0 kW | $660 to $3,300 |
| SDMO Generators | .9 to 9KW | na |
| Stow (Multiquip) | 2.9 to 4.5 kW | na |
| Trillium International | na | na |
| Troy-Bilt | 1.0kW to 7.5kW | $399 to $1099 |
| Tsurami (construction) | 2.5 to 5.0kW | $1200 to $2300 |
| Voltmaster | 3.0 to 15kW | $435 to $3,600 |
| Walbro Engine Management | na | na |
| Wheelhouse | 4.0 to 5.5kW | $650 to $750 |

**Table 1 (continued): Manufacturers and Suppliers of Portable Electric Generators ***

| Manufacturer/Model | Output Rating | Price Range |
|---|---|---|
| WINCO | 3.0 to 15kW | $886 to $4,362 |
| Winpower | 2.5 to 15kW | $668 to $4,360 |
| Yamaha | 1 to 12 kW | $600 to $3,800 |
| Yanmar (Diesel) | na | na |
| Wacker | 3.7 to 9.7kW | $1,390 to $3,332 |
| Westerbeke (marine applications) | Na | na |

*Actively marketing in 2003/2004.

References:


1. *Residential Generators, Selection, Installation and Use*, EPRI PEAC Corporation, July 1999.
2. *Generator Selection Guide/Consumer Report on Generators,* www.bowerspower.com, 2/2/04.
3. *World Generator Set Market to Experience Slow Growth in 2004, the First Time in Three Years, claims ABI,* ABI Press Release, 1/29/04, www.abiresearch.com
4. *Email correspondence from Philip Carlson, US EPA to Janet Buyer,* US CPSC, November 13, 2003.
5. *Non-Road Engines & Fuels Future Regulations Presentation,* Presented to MSTRS-Nonroad Working Group, January 16, 2001, Engine Manufacturers Association.
6. Blakinship, Steve, *Power to the People, Power Engineering,* May 2001.
7. Hoyle, John Christian, *Y2K Fuels A Surge in Generator Sales, Christian Science Monitor,* February 17, 1999, Vol. 91, Issue 56..
8. *Generators: Power in a Pinch, Consumer Reports,* November 2003, pps. 42-44.
9. *North American Portable Power Markets, Analyst Presentation,* Frost & Sullivan, *www.frostandsullivan.com*
10. *North American Portable Power Markets, Research Overview,* Frost & Sullivan, *www.frostandsullivan.com*
11. *Form 10-K, Annual Report*, June 29, 2003, Briggs & Stratton Corporation.
12. *North American Light Duty Portable Generator Markets,* Frost & Sullivan, 2003.
13. Lore, David, *Sales of Portable Generators Light Up, The Columbus Dispatch,* April 5, 1999.
14. Vagts, Susan, *"Incidents, Deaths, and In-Depth Investigations Associated with Carbon Monoxide and Engine Driven Tools, 1990-2003,* March 8, 2004.

# TAB C

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

# MEMORANDUM

February 27, 2006

**To:** Janet L. Buyer,
Project Manager, Portable Generator Project,
Division of Combustion and Fire Sciences, Directorate for Engineering Sciences

**Through:** Hugh McLaurin,
Associate Executive Director,
Directorate for Engineering Sciences

Randy Butturini,
Acting Director, Division of Electrical Engineering,
Directorate for Engineering Sciences

**From:** Andrew M. Trotta,
Electrical Engineer, Division of Electrical Engineering,
Directorate for Engineering Sciences

**Subject:** Description of a Typical Transfer Switch Setup for Properly Interfacing a Portable Generator with the Installed Household Wiring

This memorandum provides a description of a typical transfer switch used in a residential application to switch between utility power and generator power when using the household installed distribution system to carry backup generator power to desired electrical load equipment and appliances.* For these purposes, a transfer switch may be a discrete electrical device or assemblage of components that collectively perform this function. A typical setup is shown in Figure 1 below. Reasons for using the household wiring to distribute power from a portable generator as opposed to directly supplying the equipment through extension cords include the preference of eliminating long runs of extension cords and the necessity of powering loads that are hard-wired, such as a furnace blower, lighting circuits, sump pumps and well pumps. In order to safely and properly interface the generator output to the installed household wiring, a suitable means such as a transfer switch is needed.

A transfer switch gives the user the capability of selecting the power source (utility or backup generator) literally with the flick of a switch (or two). Generally, portable generators only have sufficient power capacity to supply a portion of the household electrical equipment. Therefore, a transfer switch may serve as a supplemental panel to the main electrical panel to supply power only to select circuits. In an installation of a typical multi-circuit transfer switch like that shown in Figure 1, the backed-up circuits are moved from the existing main electrical

* This memorandum was prepared by CPSC staff and has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

panel to the transfer switch panel, and a cable is routed from the main panel to the transfer panel. A cable from the output of the generator would be connected to the transfer switch as well. During normal operation, the backed-up circuits are powered from utility power via the transfer switch. When utility power is lost, the user starts the generator then opens the utility circuit breaker in the transfer switch enclosure and closes the generator circuit breaker in the transfer switch.

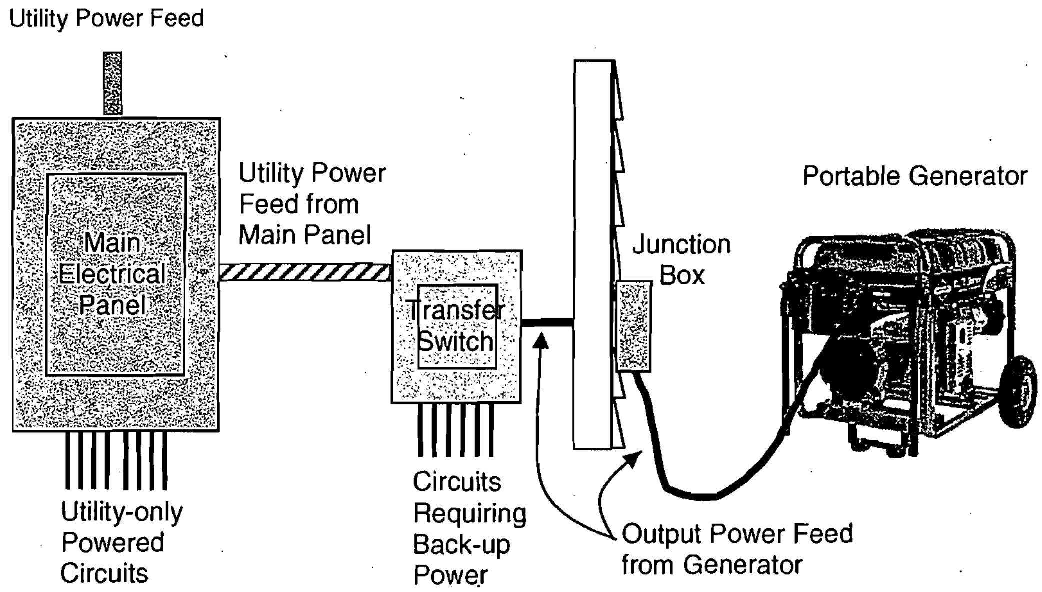



**Figure 1. An example of a typical transfer switch setup for properly interfacing a portable generator with the installed household wiring.**

Some electrical panel manufacturers also offer a conversion kit for the main electrical panel to insert a special circuit breaker into the main panel to accept power from a generator to supply the entire panel from the portable generator. The kit includes a mechanical interlock that only permits one source (utility or generator) to supply power at a time. This type of system is less expensive and offers the flexibility of being able to supply power to any circuit (load), but it requires prudence from the user to appropriately select which circuits to supply and which to turn off so as not to overload the generator.

# TAB D

**UNITED STATES**
**CONSUMER PRODUCT SAFETY COMMISSION**
**WASHINGTON, DC 20207**

**Memorandum**

Date: December 1, 2005

TO : Janet Buyer
Project Manager, Division of Combustion and Fire Sciences
Directorate for Engineering Sciences

THROUGH: Russell H. Roegner RR
Associate Executive Director, Directorate for Epidemiology

FROM : Natalie E. Marcy RR for NM
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SUBJECT : Incidents, Deaths, and In-Depth Investigations Associated with Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 1990-2004

This memorandum summarizes carbon monoxide (CO) incidents from the Consumer Product Safety Commission (CPSC) databases that were associated with engine-driven generators and other engine-driven tools that occurred between 1990 and 2004.[1] Other engine-driven tools include tools such as power lawn mowers, garden tractors, portable pumps, power sprayers and washers, snow blowers, and floor buffers. This memorandum summarizes the characteristics of CO poisoning deaths and investigated incidents reported to CPSC associated with engine-driven tools. This memorandum also provides a more detailed summary of fatal CO poisoning incidents associated with engine-driven tools found in CPSC's In-depth Investigation (INDP) File.

The following CPSC databases were searched: the In-depth Investigation (INDP) File, the Injury or Potential Injury Incident (IPII) File, and the Death Certificate (DTHS) File. See Appendix A for the codes and keywords used in the database searches. It should be noted that reporting may not be complete, and this memorandum reflects only those incidents entered into CPSC databases before June 27, 2005. All CO incidents found during the database search that were associated with at least one CO fatality or a non-fatal exposure to CO that resulted in one or more individuals attending a medical facility for treatment were included. Appendix B provides a listing of the incidents referenced in this memorandum.

Twenty-two incidents associated with both an engine-driven tool and a non-engine driven tool source of CO (such as a gas space heater or water heater) were considered out of scope for this

[1] This analysis was prepared by the CPSC staff, has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

memo, since the exact source of the CO could not be determined.[2] Incidents associated with multiple engine-driven tools (such as a generator and a lawn mower) were included. Incidents associated with generators that were specifically reported as integral parts of recreational vehicles (RVs), motor homes, or boats were not included. For example, generators that were reported as mounted to the bottom of an RV were not included, nor were boat generators that were installed by the boat manufacturer. Since incidents in recreational vehicles and boats can be associated with either a portable generator or an integral generator, those incidents in which the type of generator was not specifically stated were excluded from the analysis. For one fatal incident in a boat and two separate fatal incidents in a motor home, CPSC staff could not specifically conclude that the generator was an integral part of the boat or motor home. In addition, a non-fatal incident in a camper and a non-fatal incident in a boat were associated with generators where it could not be specifically determined if the generator was an integral part.[3] Therefore these five incidents were excluded. Also, one incident that was determined to be work-related was not included.[4]

**Table 1: Number of Non-fire Carbon Monoxide Potential Exposure Incidents and Deaths Reported to CPSC Associated with Engine-Driven Tools, 1990-2004**

| Product | Number of Incidents | Number of Deaths |
|---|---|---|
| **Total** | **317** | **318** |
| Generator | 263 | 274 |
| Garden tractor and lawn mower | 35 | 33 |
| Snow blower | 5 | 5 |
| Floor buffer | 3 | 0 |
| Pumps | 3 | 2 |
| Power washer and sprayer | 4 | 1 |
| Other engine-driven power tools or internal combustion engine (non-vehicular) | 3 | 2 |
| Multiple engine-driven tools | 1 | 1 |

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2005

Table 1 shows the number of carbon monoxide exposure incidents and deaths in CPSC files associated with generators and other engine-driven tools that occurred between January 1, 1990 and December 31, 2004. Staff found in CPSC's files 317 incidents and 318 deaths that occurred between 1990 and 2004 inclusive involving engine-driven tools and a potential CO exposure. The term *potential* is used to characterize these incidents because the CO exposure could not be confirmed for some of the non-fatal incidents. Incidents were associated with portable generators, garden tractors, lawn mowers, snowblowers, floor buffers, portable pumps, power washers and sprayers, other engine-driven power tools, and multiple engine-driven tools. The category 'other engine-driven power tools' includes gas floor and concrete cutters. The category

[2] 0021038891, 0156001192, 0227037489, 0302000494, 030219HEP9015, 9845030920, 9926010886, B9529423A, G9130305A, N0120209A, X0231359A, X0310578A, X0331336A, X9122456A, X9176126A, X9621373A, 0134003962, 0218009073, 0218008207, 0355044625, 0451005498, and X0452231A.

[3] These incidents were excluded from the analysis: X99B3684B and 010301HEP9009 (non-fatal incidents); and 9522020180, G9160205A, and N9470214A (fatal incidents). In all five of these incidents, the integral nature of the involved generator was unknown. These incidents were included in analyses in previous memoranda.

[4] This incident was excluded: 050223HCC1506.

‘multiple engine-driven tools’ includes an incident that involved both a generator and a power lawn mower.

Two hundred and sixty-three of the 317 incidents reported to CPSC were associated with generators. Two hundred seventy-four (86%) of the deaths were associated with generators. Throughout the remainder of this memo, incidents associated with all engine-driven tools will be reported as a group. In addition, since the majority of incidents were associated with portable generators, characteristics of these incidents will be reported separately.

CPSC staff examined the number of deaths occurring during each incident (Table 2). Twenty-two percent of the CO exposure incidents reported to CPSC and associated with an engine-driven tool were not associated with a CO poisoning fatality. Of those incidents that did involve at least one death (246 incidents), 77% involved a single fatality. Seventy-three percent of fatal generator incidents involved a single fatality. Of the 43 fatal incidents in the ‘all other engine-driven tools’ category, all but one incident were associated with a single fatality. The one multiple CO fatality incident in this category involved a sump pump.

**Table 2: Number of Carbon Monoxide Poisoning Incidents Reported to CPSC by Number of Deaths per Incident, 1990-2004**

| Number of Deaths Reported in Incident | Total | | Generator | | All Other Engine-Driven Tools | |
|---|---|---|---|---|---|---|
| **Total Incidents** | **317** | **(100)** | **263** | **(100)** | **54** | **(100)** |
| 0 | 71 | (22) | 60 | (23) | 11 | (20) |
| 1 | 190 | (60) | 148 | (56) | 42 | (78) |
| 2 | 45 | (14) | 44 | (17) | 1 | ( 2) |
| 3 | 6 | ( 2) | 6 | ( 2) | 0 | ( 0) |
| 4 | 5 | ( 2) | 5 | ( 2) | 0 | ( 0) |

Note: Numbers in parentheses represent percentages. Totals may not add to 100% due to rounding.
Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2005

Due to the difficulties in defining a CO poisoning injury or confirming a CO exposure, the remainder of this memorandum will focus only on CO poisoning incidents that involved a death associated with an engine-driven tool. Throughout this memorandum, the number of deaths represents the actual number of deaths that have been entered in the CPSC databases by June 27, 2005. The count is the unweighted, actual number of CO poisoning deaths in the CPSC files associated with generators and other engine-driven tools.

CPSC staff summarized the number of reported deaths associated with engine-driven tools by year of death (Table 3). It should be noted that the figures in Table 3 represent the numbers of deaths reported to CPSC as of June 27, 2005. Some deaths are reported to CPSC shortly after an incident occurs, while other deaths are reported to CPSC months or years after an incident occurs. Therefore, counts for more recent years may not be as complete as counts for earlier years. It should also be noted that death certificates for years 1999 and later were coded under the Tenth Revision of the International Classification of Diseases (ICD-10). With the transition to ICD-10 in 1999, the types of death certificates purchased by CPSC changed. These changes could affect the numbers of deaths associated with engine-driven tools that are reported to CPSC. Prior to 1999, these deaths were normally coded with an ICD-9 e-code (868.2) for motor vehicle exhaust deaths. These death certificates were not routinely purchased by CPSC. Occasionally, some death certificates that were related to the products in this memo were reported to CPSC under other e-codes, (usually under e-codes 868.8 [carbon monoxide from other sources] and 868.9 [unspecified carbon monoxide]). In January of 1999, CPSC began purchasing death certificates classified in ICD-10 codes that contain all unintentional CO poisoning deaths associated with all sources of carbon monoxide, including motor vehicles.

**Table 3: Number of Non-fire Carbon Monoxide Poisoning Deaths Reported to CPSC Associated with Engine-Driven Tools By Year, 1990-2004**

| Year | Total | Generators | All Other Engine-Driven Tools |
|---|---|---|---|
| **Total** | **318** | **274** | **44** |
| 1990 | 18 | 18 | 0 |
| 1991 | 4 | 3 | 1 |
| 1992 | 7 | 7 | 0 |
| 1993 | 14 | 11 | 3 |
| 1994+ | 8 | 5 | 3 |
| 1995+ | 11 | 10 | 1 |
| 1996 | 20 | 17 | 3 |
| 1997 | 20 | 18 | 2 |
| 1998 | 14 | 13 | 1 |
| 1999* | 11 | 6 | 5 |
| 2000 | 26 | 20 | 6 |
| 2001 | 21 | 18 | 3 |
| 2002 | 47 | 42 | 5 |
| 2003 | 57 | 51 | 6 |
| 2004 | 40 | 35 | 5 |

* The ICD-10 system was implemented in 1999
+ The number of deaths associated with engine-driven products in 1994 and 1995 differ from those reported in the annual estimate report.[5,6] This is due to the exclusion of products that were integral parts of boats in this report.
Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2005

Staff further examined reported deaths associated with engine-driven tools by the season when the incident occurred (Table 4). Seasons were defined as winter (December, January, and February), spring (March, April, and May), summer (June, July, and August), and fall (September, October, and November). About 39 percent of the deaths associated with an engine-driven tool occurred in the winter.

[5] Ault K. "Estimates of Non-fire Carbon Monoxide Poisoning Deaths and Injuries," Washington, D.C.: U.S. Consumer Product Safety Commission. 1997.
[6] Mah J. "Non-Fire Carbon Monoxide Deaths Associated with the Use of Consumer Products, 1998 Annual Estimates." Washington, D.C.: U.S. Consumer Product Safety Commission. 2001.

**Table 4: Number of Non-fire Carbon Monoxide Poisoning Deaths Reported to CPSC and Associated with Engine-Driven Tools by Season, 1990-2004**

| Season Incident Occurred | Number of Deaths Reported to CPSC | | | | | |
|---|---|---|---|---|---|---|
| | All Engine-Driven Tools | | Generators | | All Other Engine-Driven Tools | |
| **Total** | **318** | **(100)** | **274** | **(100)** | **44** | **(100)** |
| Winter | 124 | (39) | 108 | (39) | 16 | (36) |
| Spring | 50 | (16) | 39 | (14) | 11 | (25) |
| Summer | 65 | (20) | 56 | (20) | 9 | (20) |
| Fall | 79 | (25) | 71 | (26) | 8 | (18) |

Note: Numbers in parentheses represent percentages. Totals may not add to 100% due to rounding.
Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2005

There were 12 reported incidents relating to the 2004 hurricane season that involved a CO poisoning death or injury that received medical treatment. There were eight hurricane-related deaths reported, five of which occurred in Florida.[7] There were 29 reported injuries that resulted in medical treatment.

Incidents involving deaths were further examined in Table 5 by the location where the death occurred. The majority of CO poisoning deaths (77%) reported to CPSC and associated with engine-driven tools occurred at a home, which included single-family homes, apartments, and mobile homes. The home location also includes garages or sheds at homes or residences. The temporary shelter category includes trailers, horse trailers, motor homes, recreational vehicles, vans, cabins, and campers. The 'other' category includes incidents occurring in some of the following locations: bar, building, church, greenhouse, mineshaft, public place, and storage shed (offsite from home).

**Table 5: Number of Non-fire Carbon Monoxide Poisoning Deaths Reported to CPSC and Associated with Engine-Driven Tools by Location, 1990-2004**

| Location | Number of Deaths Reported to CPSC | | | | | |
|---|---|---|---|---|---|---|
| | All Engine-Driven Tools | | Generators | | All Other Engine-Driven Tools | |
| **Total** | **318** | **(100)** | **274** | **(100)** | **44** | **(100)** |
| Home | 246 | (77) | 204 | (74) | 42 | (95) |
| Temporary shelter | 40 | (13) | 40 | (15) | 0 | ( 0) |
| Boat | 7 | ( 2) | 7 | ( 3) | 0 | ( 0) |
| Other | 12 | ( 4) | 12 | ( 4) | 0 | ( 0) |
| Not reported | 13 | ( 4) | 11 | ( 4) | 2 | ( 5) |

Note: Numbers in parentheses represent percentages. Totals may not add to 100% due to rounding.
Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2005

[7] There was one case, 050223HCC1506, that was not included in this count because the incident was work-related. It was, however, included in the count of cases reported in the MMWR article entitled Carbon Monoxide Poisonings from Hurricane-Associated Use of Portable Generators – Florida, 2004, July 22, 2005.

Tables 6 and 7 present the distribution of age and sex of the deceased in the incidents. Table 6 shows that adults aged 25 years and older accounted for about 83% of reported CO poisoning deaths associated with all engine-driven tools. Adults age 25 years and older accounted for about 81% of CO poisoning deaths associated with generators and accounted for all deaths associated with other engine-driven tools. Males accounted for 75% of the deaths associated with all engine-driven tools and 71% of the deaths associated with generators. One female death was associated with a sump pump, and another female death was associated with a lawn mower in a different incident; both of these deaths were categorized as 'all other engine-driven tools'.

**Table 6: Non-Fire Carbon Monoxide Poisoning Deaths Reported to CPSC and Associated with Engine-Driven Tools by Age of Victim, 1990-2004**

| Age | Number of Deaths Reported to CPSC | | | | | |
|---|---|---|---|---|---|---|
| | All Engine-Driven Tools | | Generators | | All Other Engine-Driven Tools | |
| **Total** | **318** | **(100)** | **274** | **(100)** | **44** | **(100)** |
| Under 5 | 8 | ( 3) | 8 | ( 3) | 0 | ( 0) |
| 5 – 14 | 20 | ( 6) | 20 | ( 7) | 0 | ( 0) |
| 15 – 24 | 19 | ( 6) | 19 | ( 7) | 0 | ( 0) |
| 25 – 44 | 99 | (31) | 90 | (33) | 9 | (21) |
| 45 – 64 | 105 | (33) | 83 | (30) | 22 | (50) |
| 65 and over | 61 | (19) | 48 | (18) | 13 | (30) |
| Unknown | 6 | ( 2) | 6 | ( 2) | 0 | ( 0) |

Note: Numbers in parentheses represent percentages. Totals may not add to 100% due to rounding.
Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2005

**Table 7: Non-Fire Carbon Monoxide Poisoning Deaths Reported to CPSC and Associated with Engine-Driven Tools by Sex of Victim, 1990-2004**

| Sex | Number of Deaths Reported to CPSC | | | | | |
|---|---|---|---|---|---|---|
| | All Engine-Driven Tools | | Generators | | All Other Engine-Driven Tools | |
| **Total** | **318** | **(100)** | **274** | **(100)** | **44** | **(100)** |
| Male | 237 | (75) | 195 | (71) | 42 | (95) |
| Female | 81 | (25) | 79 | (29) | 2 | ( 5) |

Note: Numbers in parentheses represent percentages. Totals may not add to 100% due to rounding.
Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2005

### In-Depth Investigations of Engine-Driven Tool Incidents

Data from CPSC's In-depth Investigation File are not a statistical sample and national totals may not be derived from the number of incidents investigated. Data provide examples of actual incidents and anecdotal information. Incidents in the CPSC In-depth Investigation File were examined to obtain more detailed information about the scenarios related to CO incidents associated with engine-driven tools. Not all information examined is available for each investigation.

CPSC staff further investigated 216 of the 317 incidents referenced in this memorandum. In-depth investigations associated with engine-driven tools have been requested more frequently in recent years. For example, 94% of the incidents associated with engine-driven tools that were reported to CPSC were investigated in 2004, and only 10% of the incidents were investigated in 1990. Of the 216 in-depth investigations investigated, 164 involved at least one fatality. These 164 in-depth investigations of fatal incidents involved 216 deaths. One hundred and eighty-nine of these deaths were associated with generators and 27 deaths were associated with other engine-driven tools.

Pre-existing health conditions affecting the heart, lungs, liver, and circulatory system can increase an individual's susceptibility to elevated carboxyhemoglobin (COHb) levels in the bloodstream, increasing the risk of a fatal CO exposure. Although this information was not available for all investigated deaths, 22 of the 216 CO deaths investigated that were associated with engine-driven tools involved individuals who had pre-existing health conditions not related to CO poisoning at the time of death.

Alcohol and drug use can act as a central nervous system depressant causing dulled reactions, which could likely impair a person's ability to react appropriately to a CO hazard, thus potentially prolonging exposure and increasing the chance of a fatal outcome. Although this information was not available for all investigated deaths, 39 of the 216 deaths investigated noted that the victim had used alcohol or recreational drugs during the time period surrounding the incident.

*In-Depth Investigations Associated with a Fatal CO Poisoning and a Generator*

CPSC staff further explored the 189 fatalities, which involved 137 in-depth investigations of fatal generator incidents. The characteristics of age and sex of victim, location of death, and number of fatalities per incident were similar in the total group of reported deaths associated with generators to those that were further investigated. About 82% of the deaths reported to CPSC involved adults aged 25 years and older, and about 80% of the deaths investigated involved adults 25 years and older. Males accounted for 71% of the reported CO deaths associated with generators and 67% of deaths investigated. The location of the death was also similar for those cases that were investigated versus all CO poisoning deaths reported. The majority of deaths investigated (77%) occurred in a home, while 73% of deaths reported occurred in a home. Fifteen percent of the deaths investigated occurred in a temporary shelter, while 16% of the total reported deaths occurred in a temporary shelter. Incidents investigated that involved at least one death were similar to reported generator incidents that involved at least one death in that 77% of all the fatal incidents reported involved a single fatality, while 70% of the investigated deaths involved a single fatality.

Information provided in investigations that was not available as regularly from the Injury or Potential Injury Incident (IPII) File and Death Certificate (DTHS) File source documents included information about the specific location of the generator, the venting of the generator, the rating of the generator, the fuel used with the generator, the reason the generator was being used, whether the generator was owned by the deceased or a member of the deceased's household, the concentration of the CO at the location where the generator was used, and the carboxyhemoglobin (COHb) levels of the deceased.

The main reasons reported for using a generator were to provide electricity to a location that did not have electricity due to a temporary situation, or to provide power to a temporary location. Sixty investigated deaths involved generators used during a temporary power outage stemming from a weather problem or a problem with power distribution; 39 investigated deaths involved generators used to supply power to a temporary shelter, storage-shed (offsite from the home), or boat that did not have electricity; 23 investigated deaths involved generators used in a situation where the utility company, often because of an overdue payment, turned off the power; 26 investigated deaths were associated with locations where the electricity was off due to another reason, such as recent fire at the location, the home was abandoned, the home was a new home that did not have electricity at the time of the incident, the residents of the home requested that the electricity be turned off, or a home was undergoing a remodeling project. Twenty-five of the deaths investigated involved incidents where the electricity was off at the location but the reason why was unknown. Fourteen of the deaths investigated involved a generator used in a more permanent situation, such as to supply power to a home or mobile home that did not normally have electricity or to provide power to a garage of a home. Two deaths were associated with incidents where the user was repairing a generator or was preparing the generator for use due to forecasted bad weather.

**Table 8: In-Depth Investigations Associated with Generators and Carbon Monoxide Poisoning Deaths in the Home by Location of the Generator, 1990-2004**

| Generator Location | Number of Deaths |
|---|---|
| **Total** | **146** |
| Basement/crawl space | 48 |
| Garage/enclosed carport | 41 |
| Living space | 33 |
| Inside house, no further information reported | 8 |
| Closet | 3 |
| Doorway | 2 |
| Outside home | 7 |
| Shed | 2 |
| Other, inside a nearby mobile home | 1 |
| Unknown location, but at home | 1 |

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2005

In-depth investigations of CO deaths that occurred in a home were further classified by the specific location of the generator (Table 8). The category 'living space' includes rooms reported as bedrooms, bathrooms, dens, living rooms, landings, offices, rear rooms, enclosed porches, and converted garages. The category 'outside home' includes incidents where the generator was placed outside a home but near an open window, door, or vent of the home. Although this information was not available for all incidents, 30 of the deceased individuals were found in the same room or space of the home as the generator, and 105 of the deceased individuals were found in different rooms or spaces of the home. In some cases, individuals were found in rooms located above the basement or in rooms next to or above the garage where the generator was located.

Conclusions about a consumer's reasons for placing a generator indoors, along with determinations of the consumer's awareness of the carbon monoxide hazard associated with the use of a generator in an enclosed space, are difficult to make from information obtained in the typical investigation. The reason a generator was operated in a certain location was provided in the investigations for only 32 deaths. The most common reason mentioned for using the generator indoors was that the user feared that someone might steal the generator (11 deaths). Other reasons for using the generator indoors included: to muffle the sound (6 deaths), the users didn't want the neighbors to know their electricity had been turned off (3 deaths), complaints of property owners or neighbors (2 deaths), a user attempting to fix a generator (1 death), users not realizing their generators should be operated outside (5 deaths), a case in which the user ran the generator outside, where it would stall, so the user operated it inside for some time and then put it back outside (1 death), and cases in which an attempt was made to directly vent the generator exhaust to the outside (3 deaths).

There was little information available in the investigations about whether users were aware of the CO hazard associated with using generators indoors. Some investigations reported that family, friends, or landlords stated that they had forewarned the user of the potential CO hazard, but otherwise there was no way to assess whether users were or were not aware of the CO issue.

Many of the death investigations (85 of the 189 deaths investigated) did not contain information about the exact venting of the generator. In 63 of the 104 deaths investigated in which information on the venting was available, the generators were not vented at the time of the incident. In one investigated death where there was no venting, the room with the generator was thought to be sealed off from the rest of the house. There were 40 investigations that reported that some type of venting was employed. Twenty-four investigated deaths reported an open window, an open door, an open garage door, or a combination of these. In five investigated deaths, a window or door was open during some period of use but later closed. Five investigated deaths were associated with a generator that was placed outside the home near an open window, door, or vent. Two investigated deaths were associated with a portable generator used on a boat; the users attempted to vent the generator by modifying the exhaust system in place for an installed generator. In one investigated death the associated generator was operated outdoors for some time. It would stall and would then be operated in the doorway for a period of time. In three investigated deaths, the generator exhaust was directly vented to the outside but the vent leaked.

The size of the generator and the fuel used with the generator were both examined. The size of the generator was examined by the wattage rating (Table 9). In most cases, the running wattage rating was used to categorize a case. In some instances, however, a wattage rating was obtained but it could not be determined whether this rating was the rated running wattage or maximum/surge wattage. For 32 incidents in which the in-depth investigation provided the make, model, and/or engine size of the associated generator but not the wattage rating, CPSC staff used the identifying information to ascertain the power rating. When the wattage rating of the generator was known or could be determined (108 investigated deaths), 53 investigated deaths were associated with a generator in the five-kilowatt rating range. Almost all of the generators were referred to as gas or gasoline generators. One generator was identified as a propane generator and one was identified as a natural gas generator.

**Table 9: Wattage Rating Reported in In-Depth Investigations Associated with Generators and a Carbon Monoxide Poisoning Death, 1990-2004**

| Wattage Rating (in Kilowatts) | Number of Deaths |
|---|---|
| **Total** | **189** |
| Under 1 | 3 |
| 1-1.9 | 7 |
| 2-2.9 | 8 |
| 3-3.9 | 20 |
| 4-4.9 | 8 |
| 5-5.9 | 53 |
| 6-6.9 | 8 |
| Greater than 7 | 1 |
| Not reported | 81 |

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2005

In many of the investigations (109 of the 189 fatalities), staff could not determine whether the generator was owned by the deceased or a member of the deceased's household, whether it was borrowed, or whether it was rented. In the investigations of 41 of the deaths, the deceased or a member of the deceased's household owned the generator. In investigations of 33 of the deaths, staff determined that the generator was borrowed. In investigations of six of the deaths, the generator was rented.

**Table 10: Carboxyhemoglobin Levels Reported in In-Depth Investigations Associated with Generators and a Carbon Monoxide Poisoning Death, 1990-2004**

| COHb Level | Number of Deaths |
|---|---|
| **Total** | **189** |
| Less than 30% | 2 |
| 30-39.9% | 4 |
| 40-49.9% | 12 |
| 50-59.9% | 14 |
| 60-69.9% | 38 |
| 70-79.9% | 29 |
| 80-89.9% | 10 |
| 90-99.9% | 1 |
| Not Reported | 79 |

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2005

Carboxyhemoglobin (COHb) levels were provided in the investigations for 110 of the 189 fatalities. Table 10 provides a breakdown of the COHb levels. In healthy adults, a COHb level of 40 to 50% approximately correlates with symptoms of 'confusion, unconsciousness, coma, possible death'; a level of 50 to 70% approximately correlates with symptoms of 'coma, brain damage, seizures, death'; and a level greater than 70% is 'typically fatal'.[8] The majority of individuals with reported COHb levels (92 of the 110) had levels greater than 50% COHb.

Twenty-seven investigations (associated with 36 deaths) provided ambient levels of carbon monoxide at the location, measured as parts per million (ppm). Some values were measured only after the location had been vented and/or the generator had been shut down, often because the generator had run out of fuel, for some time prior to the measurement. The six investigations that did not have maximum CO levels greater than 150 ppm reported that the location had been vented prior to the measurement of the CO level, or the measurement of the CO level took place hours after the incident. Twenty-one of the investigations had maximum CO levels that measured greater than 150 ppm: six investigations had CO levels between 150 and 299 ppm, two investigations had levels between 300 and 449 ppm, three investigations had levels between 450 and 599 ppm, and ten investigations had levels higher than 600 ppm.

*In-Depth Investigations Associated with a Fatal CO Poisoning and a Tool Included in the 'All Other Engine-driven Tool' Category*

Twenty-seven of the 44 deaths associated with other engine-driven tools were investigated further. All 27 of the incidents investigated involved a single fatality. Twenty-six of the investigated deaths involved a garden tractor or a power lawn mower, although one investigation involved both a generator and a power lawn mower. One investigated incident involved a gas concrete cutter. All the deceased in these investigations were males and roughly half of the investigations (14 out of 27) involved individuals between the ages of 45-64. Five fatal investigations involved deaths of individuals in the 25-44 age group and eight fatal investigations involved deaths of individuals in the 65-and-over age group.

**Table 11: Carboxyhemoglobin Levels Reported in In-Depth Investigations Associated with Other Engine-driven Tools and a Carbon Monoxide Poisoning Death, 1990-2004**

| COHb Level | Number of Deaths |
|---|---|
| **Total** | **27** |
| 30-39.9% | 1 |
| 40-49.9% | 3 |
| 50-59.9% | 5 |
| 60-69.9% | 6 |
| 70-79.9% | 6 |
| 80-89.9% | 4 |
| Unknown Level | 2 |

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2005

For 25 of the 27 deceased, the carboxyhemoglobin level was provided (Table 11). Ambient CO levels were provided in only four of the investigations. One investigation reported an ambient CO level of 20 ppm in the garage and a maximum of 80 ppm in the house. These measurements were taken after venting. One investigation reported a maximum ambient CO level of 740 ppm

[8] Burton LE. Toxicity from Low Level Human Exposure to Carbon Monoxide. Washington, D.C.: U.S. Consumer Product Safety Commission. 1996.

with the doors open. For the two other incidents reported, ambient CO levels of 101 ppm and 76.9 ppm were recorded when the police or fire department responded to the scene after the deceased had been discovered.

All 26 of the investigated deaths associated with a lawn mower or garden tractor occurred in an enclosed space at a home, with 14 investigated deaths occurring in the garage of a home, 11 in the shed of a home, and one in a utility building. Twenty-two of these investigations provided details as to why the lawn mower or garden tractor was being used within an enclosed space. The majority of these investigated deaths (17 out of 22) involved the victim working on or repairing a garden tractor or power lawn mower within an enclosed space. The one death associated with the concrete cutter occurred in the basement of a home.

**Conclusion**

Between 1990 and 2004 there were 318 CO poisoning deaths reported to CPSC that were associated with engine-driven tools. The majority of these deaths (274) involved generators. Other engine-driven tools that were associated with a much smaller number of deaths included garden tractors, lawn mowers, snow blowers, pumps, power washers or sprayers, and other engine-driven power tools. The majority of fatal incidents reported to CPSC involved a single fatality. Most reported deaths occurred while an individual was at home.

Adults aged 25 years and older accounted for about 81% of CO poisoning deaths reported to CPSC associated with generators, and the majority (71%) was male. Seventy-four percent of the reported deaths associated with generators occurred at home. Generators were commonly placed in the basement or garage of the home. Generators were often used as alternative sources of electricity due to temporary power outages or as power sources for temporary shelters. Generators were often used with little or no ventilation. Conclusions about why consumers used generators indoors or determinations about whether users were aware of the potential CO hazards are difficult to make with the available information.

Adults aged 25 years and older accounted for all of the CO poisoning deaths reported to CPSC associated with engine-driven tools, excluding generators. Males accounted for all but two of the 44 deaths reported to CPSC associated with other engine-driven tools. Deaths associated with garden tractors and lawn mowers were often associated with an individual repairing or working on the product in an enclosed space.

**References**

Ault K. Estimates of Non-fire Carbon Monoxide Poisoning Deaths and Injuries, memorandum. December 1, 1997. U.S. Consumer Product Safety Commission.

Burton LE. *Toxicity from Low Level Human Exposure to Carbon Monoxide.* U.S. Consumer Product Safety Commission. 1996.

Carlson S. Incidents, Deaths, and In-Depth Investigations Associated with Carbon Monoxide and Engine-Driven Tools, 1990-2003, memorandum. March 8, 2004. U.S. Consumer Product Safety Commission.

Mah J. *Non-Fire Carbon Monoxide Deaths Associated with the Use of Consumer Products, 1998 Annual Estimates.* U.S. Consumer Product Safety Commission. 2001.

Marcy NE, Ascone DS. *Non-Fire Carbon Monoxide Deaths Associated with the Use of Consumer Products, 2002 Annual Estimates.* U.S. Consumer Product Safety Commission. July 2005.

## APPENDIX A

The queries below were submitted through the EPIR application. Query results were manually reviewed to include only carbon monoxide poisoning hazards and to exclude duplicates and out-of-scope cases, which were cases that did not involve an incident that was associated with a non-fire carbon monoxide exposure and an engine-driven tool. Work-related cases were also excluded.

Date of Queries: 06/27/2004

Incident dates: 1/1/90 – 12/31/04
Product Codes: 113, 606, 809, 820, 887-888, 1062, 1400-1464
Narrative/Text contains: 'CO_' or 'CARB' or 'MONO'

## APPENDIX B

| Document Number | Investigation Task Number |
|---|---|
| NEISS | 980901HEP5441 |
| NEISS | 981118HEP1681 |
| NEISS | 990903HEP1683 |
| NEISS | 020705HEP9005 |
| NEISS | 020724HEP9004 |
| NEISS | 021219HEP9012 |
| NEISS | 030403HEP9001 |
| NEISS | 030403HEP9018 |
| NEISS | 031009HEP9007 |
| NEISS | 040901HEP9010 |
| NEISS | 041112HEP9004 |
| 0004000376 | 021031HCC3059 |
| 0005025284 | 020228HCC2282 |
| 0012022297 | 021107HCC1123 |
| 0022034412 | 010628HCC2616 |
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| 0037071040 | 011126HCC1143 |
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UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: August 16, 2006

TO : Janet Buyer, Project Manager
Division of Combustion and Fire Sciences
Directorate for Engineering Sciences

THROUGH: Russell H. Roegner, Ph.D., Associate Executive Director RR
Directorate for Epidemiology

Kathleen Stralka, M.S., PMP®, Director
Division of Hazard Analysis

FROM : Matthew V. Hnatov, Mathematical Statistician
Division of Hazard Analysis

SUBJECT : Non-fire Carbon Monoxide Fatalities Associated with Engine-Driven Generators and Other Engine-Driven Tools in 2002 through 2005

This memorandum provides an updated number of reported non-fire carbon monoxide fatalities associated with engine-driven generators and other engine-driven tools that occurred from 2002 through 2005[1]. This memorandum includes fatalities reported as of June 1, 2006. These are preliminary counts of incidents for the time period covered since reporting is not complete for these years. An earlier memorandum titled "Incidents, Deaths, and In-Depth Investigations Associated with Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 1990-2004," dated December 1, 2005 included fatalities through December 31, 2004 and reported as of June 27, 2005. The criteria used to search the data for the December 1, 2005 memorandum and this memorandum are similar. The search criteria for non-generator engine-driven tools was expanded in an effort to capture other engine-driven tools that may not have been captured by the criteria used in the December 1, 2005 memorandum.

Fatality counts are provided in two separate tables. Table 1 provides fatality counts associated with a specific engine-driven tool. Table 2 provides additional fatality counts that could not solely be associated with an engine-driven tool since other possible carbon monoxide producing products were also in use at the time of death. In all but two of the fatalities summarized in Table 2, the additional product in use was a heating device – kerosene or propane heater or a wood burning stove. Of the two exception cases, one case involved both a running generator and vehicle in a closed garage. In the other case, there was a generator and heater running and possibly a second heater, propane lantern and/or gas camp stove in use. The data in Table 2 are

[1] This analysis was prepared by the CPSC staff, has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

not included in Table 1 but are provided as additional information on carbon monoxide fatalities where an engine-driven tool was a likely contributing factor.

**Table 1: Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools: 2002 - 2005***

| | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|
| All Engine-Driven Tools | 48 (+1) | 65 (+8) | 49 (+9) | 73 |
| Generators | 43 (+1) | 56 (+5) | 42 (+7) | 64 |
| Other Engine-Driven Tools | 5 (0) | 9 (+3) | 7 (+2) | 9 |
| Air Compressor | 0 | 0 | 1 (+1) | 0 |
| Concrete Saw | 1 (0) | 0 | 1 (+1) | 0 |
| Lawn Mower/Tractor | 4 (0) | 6 (+2) | 5 (0) | 6 |
| Paint Sprayer | 0 | 1 (+1) | 0 | 0 |
| Pressure Washer | 0 | 0 | 0 | 1 |
| Snow Blower | 0 | 0 | 0 | 1 |
| Welder | 0 | 2 (0) | 0 | 1 |

* Fatality counts are those reported to CPSC as of 6/1/2006. Parenthetical counts are the additional reported fatalities received by CPSC and added to those reported in the December 1, 2005 memorandum.

**Table 2: Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools Used in Conjunction with Another Possible Carbon Monoxide Source: 2002 - 2005***

| | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|
| All Engine-Driven Tools | 6 | 6 | 2 | 6 |
| Generators | 5 | 5 | 1 | 6 |
| Other Engine-Driven Tools | 1 | 1 | 1 | 0 |

* Fatality counts are those reported to CPSC as of 6/1/2006.

<u>Search Criteria Used to Identify Relevant Cases</u>

Databases Searched: DTHS, INDP, IPII, NEISS

Incident Dates: 1/1/1990 – 12/31/2005 (reported as of 6/1/2006)

Product Codes:

| | |
|---|---|
| 113-115 | Floor Buffers, Rug Shampooers, Vacuum Cleaners |
| 606 | Generators |
| 800-896 | Shop and Construction Equipment |
| 1062 | Tractors, Other or Not Specified |
| 1400-1464 | Lawn and Other Outside Equipment |

Text Search: "CO_" or "CARB" or "MONO"

# TAB E

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

**Memorandum**

Date: December 14, 2005

TO : Jacqueline Elder, Assistant Executive Director
Office of Hazard Identification and Reduction

THROUGH : Hugh McLaurin, Associate Executive Director
Directorate for Engineering Sciences

Margaret Neily, Division Director
Division of Combustion and Fire Sciences

FROM : Janet Buyer, Project Manager
Division of Combustion and Fire Sciences
Directorate for Engineering Sciences

SUBJECT : Generator-related Deaths, Injuries, and Complaints of Potential Injury Due to Shock, Electrocution, Fires, and Burns reported to CPSC Since 1990*

CPSC staff searched CPSC databases for generator-related deaths, injuries, and complaints of potential injury due to shock and electrocution as well as fires and burns that have occurred since 1990. The following CPSC databases were searched: the In-depth Investigation (INDP) File, the Injury or Potential Injury Incident (IPII) File, the Death Certificate (DTHS) File, and the National Electronic Injury Surveillance System (NEISS).

The compilation of those incidents from each of the databases is attached. The criteria used to search each database as well as the dates of the queries are provided at the top of each table. Out-of-scope incidents and duplicate incidents within and between the databases were removed.

* This analysis was prepared by the CPSC staff. It has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

**The National Electronic Injury Surveillance System (NEISS)**
Date of Query: 11/04/2005
Incident Dates: 01/01/1990 - 11/04/2005
Product Code: 606
Diagnosis: 67 (Elec. Shock)

| Date of Treatment | Location | Age | Sex | Disposition | Bodypart | Narrative |
|---|---|---|---|---|---|---|
| 07/30/94 | Public | 14 | M | Treated & Released | All Parts Body | ELECTRIC SHOCK WAS AT CARNIVAL PLUGGING IN LIGHT ON GENERATOR REPLACED LIGHT PLUGGED IT IN AND RECEIVED SHOCK NO MENTION OF WORK RELATIONSHIP |
| 07/07/96 | Unknown | 46 | F | Treated & Released | All Parts Body | I TOUCHED 2 GUIDEWIRES (110V) CONNECTING THE GENERATOR TO THE TRAILER. DX ELECTRIC SHOCK |
| 08/21/97 | Home | 66 | M | Treated & Released | All Parts Body | PT TOUCHED A PORTABLE GENERATOR AT HOME ELECTRIC SHOCK |
| 01/01/01 | Unknown | 16 | F | Treated & Released | All Parts Body | PT SHOCKED BY ELECTRIC GENERATOR, BILATERAL UPPER EXTREMITY MYALGIAS STATUS POST ELECTRICAL SHOCK |

**The Injury or Potential Injury Incident (IPII) File**
Date of Query: 11/04/2005
Incident Date: 01/01/1990 -11/04/2005
Product Code: 606
Narrative: ‘ELECTROCUT’,’SHOCK’

| Date of Injury | State | City | Age | Sex | Disposition | Narrative |
|---|---|---|---|---|---|---|
| 02/12/92 | TX | SAN ANTONIO | 17 | M | TREATED AND RELEASED | A 17 YEAR OLD MALE WAS SHOCKED AND AN ANIMAL ELECTROCUTED AT A STOCK SHOW APPARENTLY FROM A GENERATOR, EXTENSION CORD OR FAN. |
| 11/28/92 | HI | WINDWARD | 31 | M | HOSPITALIZED | A 31 YEAR OLD MALE AND 45 YEAR OLD MALE WERE BOTH SHOCKED REFUELING PORTABLE GENERATORS WHEN ONE OF THEM BRUSHED AGAISNT FUSES ON A WALL. |
| 08/08/93 | WV | CHARLESTON | 15 | M | DOA | A 15 YEAR OLD MALE DIED WHEN APPARENTLY THERE WAS A FAULTY GENERATOR NEAR THE POOL WHERE HE WAS SWIMMING AND WAS SHOCKED. |
| 07/13/96 | NC | WASHINGTON | 73 | M | DOA | A 73 YEAR OLD MALE DIED OF ELECTROCUTION WHEN HE WAS WORKING ON A GENERATOR. |
| 02/05/98 | ME | BOWDOINHAM (SIC) | NOT RECORDED | NOT RECORDED | NO INJURY | CONSUMER HAS NOT USED GENERATOR BECAUSE IT IS NOT GROUNDED. HAS 220VOLT AND 110 VOLT RECEPTACLE. CONSUMER FEELS GENERATOR ISELECTROCUTION HAZARD. PURCHASED AS BACK-UP POWER SOURCE FOR HOUSE.NO INJURY. |
| 10/01/01 | GA | ATLANTA | NOT RECORDED | NOT RECORDED | NO INJURY | THE OWNER OF A GAS OPERATED GENERATOR REPORTS FINDING WIRES ARE RUBBED AGAINST SHEET METAL DURING USE. OWNER WAS INSTALLING WHEELS.NO INJURY, FIRE/ELECTRIC SHOCK HAZARD. |
| 06/12/04 | VA | DARVILLS | 59 | M | DOA | A MAN, AGE 59, WAS KILLED WHEN HE RECIEVED A POWERFUL ELECTRIC SHOCK WHILE USING A PORTABLE GENERATOR AT HIS HOME. |
| 09/01/05 | TX | BEAUMONT | NOT RECORDED | M | DOA | A MAN WAS ELECTROCUTED WHEN HE TRIED TO CONNECT A GENERATOR. |
| 10/04/05 | AZ | GLENDALE | 36 | M | DOA | A 36 YEAR OLD MALE WAS ELECTROCUTED WHILE TRYING TO HOOK UP A HOME GENERATOR TO A SWAMP COOLER. |

**Death Certificates (DTHS File)**
Date of Query: 11/04/2005
Date of Death: 01/01/1990 -11/04/2005
Product Code:  606
Narrative:  ‘ELECTROCUT’,’SHOCK’

| Age | Date of Death | Sex | Narrative |
|---|---|---|---|
| 45 | 02/16/90 | M | ACCIDENTIAL ELECTROCUTION WITH GENERATOR - ELECTROCUTION SEVERE ATHEROSCLEROTIC CORONARY ARTERY DISEASE WITH OLD MYOCARDIOINFARCT; LEFT VENTRICULAR HYPERTROPHY - AUTOPSY YES |
| 56 | 08/03/92 | M | ELECTROCUTION WHILE WORKING WITH GENERATOR - ELECTROCUTIONAUTOPSY YES |
| 57 | 05/14/94 | M | SUBJECT ELECTROCUTED WHILE WORKING WITH OPERATINGGENERATOR - ELECTROCUTION - AUTOPSY YES |
| 26 | 08/11/97 | M | CONTACT WITH GENERATOR - ELECTROCUTION - AUTOPSY YES |
| 50 | 08/26/98 | M | ELECTRICAL SHOCK FROM GENERATOR AT CONDOMINIUM.  SUDDEN ARRHYTHMIA. ELECTRICAL SHOCK.  AUTOPSY-YES. |

**The National Electronic Injury Surveillance System (NEISS)**
Date of Query: 12/07/2005
Date of treatment: 01/01/1990 - 12/07/2005
Product code: 606
Diagnosis: 51 (Burn - thermal)

| Date of Treatment | Location | Age | Sex | Disposition | Bodypart | Narrative |
|---|---|---|---|---|---|---|
| 06081991 | NOT RECORDED | 48 | Male | Treated & Released | Hand | GENERATOR CAUGHT ON FIRE, BURNED HAND |
| 04211993 | HOME | 38 | Male | Treated & Released | Hand | 38 YEAR OLD MALE SUFFERED 2ND DEGREE BURN TO HAND ON GENERATOR WHILE WORKING ON IT AT HOME. TREATED AND RELEASED. |
| 02181994 | NOT RECORDED | 21 MON | Male | Treated & Released | Hand | BURNS RIGHT HAND TOUCHED MUFFLER ON GENERATOR |
| 12131995 | HOME | 68 | Male | Hospitalized | Upper Trunk | PT. WAS REFILLING GASOLINE FUEL TANK ON GENERATOR AT HOME, BUT WHEN PT. RESTARTED GENERATOR IT CAUGHT ON FIRE SUSTAINED CHEST BURNS.E899 |
| 08191996 | NOT RECORDED | 17 | Female | Treated & Released | Lower Leg | PT BURNED LEG ON A HOT GENERATOR. |
| 07281997 | NOT RECORDED | 19 | Male | Treated & Released | Hand | 1ST DEGREE BURNS TO LEFT HAND WHEN TOUCHED GAS POWERED GENERATOR |
| 07111998 | HOME | 50 | Male | Treated & Released | Finger | 2ND DEGREE BURN TO LEFT THUMB AT HOME AT 3:30PM. PT BURNED THUMB WHEN TOUCHED EXHAUST OF GENERATOR. |
| 06032000 | HOME | 37 | Female | Treated & Released | Lower Leg | BURNED LOWER LEG ON A GENERATOR |
| 07192000 | NOT RECORDED | 38 | Male | Treated & Released | Lower Leg | BURN TO LEGS WHEN GENERATOR BLEW UP AND GASOLINE BURNED PT. |
| 11092000 | NOT RECORDED | 34 | Male | Treated & Released | Hand | PT SUSTAINED BURN TO HAND ON GENERATOR. |
| 04302002 | HOME | 27 | Male | Transferred | 25-50% of Body | 2ND DEGREE BURNS 30-39% TOTAL BODY SURFACE AREA-AT HOME IN GARAGE-TURNING OFF A GENERATORIN A CAMPER & IT EXPLODED-SENT TO BURN CENTER-SPRINGFIELD-FD NOT STATED |

| | | | | | | |
|---|---|---|---|---|---|---|
| 04302002 | HOME | 25 | Male | Treated & Released | Face | BURNS TO FACE-@ FRIEND'S HOUSE-A GENERATOR IN A CAMPER EXPLODED-FD NOT STATED |
| 08102002 | NOT RECORDED | 4 | Male | Treated & Released | Hand | BURNED HIS RIGHT HAND WHEN HE TOUCHED EXHAUST ON A GENERATOR. DX 2ND DEGREE BURNS OF RIGHT HAND. |
| 09152002 | HOME | 19 | Female | Treated & Released | Hand | PT BURNED HAND ON GENERATOR. DX: BURN TO LEFT HAND |
| 06202003 | NOT RECORDED | 8 | Male | Treated & Released | Hand | 2ND DEGREE BURN TO LEFT HAND. 8 YR OLD MALE GRABBED HOT EXHAUST PIPE ON A GENERATOR TONIGHT AT 9PM BURNING HIS HAND. |
| 08152004 | HOME | 54 | Female | Treated & Released | Lower Arm | PT WAS MOVING A GENERATOR AT HOME AND TOUCHED THE HOT ENGINE. SUSTAINED A THERMAL BURN TO LEFT LOWER ARM |
| 08172004 | HOME | 58 | Male | Treated & Released | Lower Leg | PT PUSHING A GENERATOR WITH HIS RIGHT LOWER LEG AT HOME. SUSTAINED A THERMAL BURN TO LOWER LEG. |
| 08182004 | HOME | 60 | Male | Treated & Released | Hand | PT TOUCHED THE HOT MUFFLER ON A GENERATOR ENGINE AT HOME SUSTAINED A THERMAL BURN TO LEFT HAND. |
| 08192004 | HOME | 50 | Male | Treated & Released | Knee | PT HIT KNEE AGAINST A HOT GENERATOR AT HOME. THERMAL BURN, KNEE. |
| 08192004 | HOME | 39 | Male | Treated & Released | Lower Arm | PT HIT RIGHT FOREARM ON A GENERATOR AT HOME. THERMAL BURN, RIGHT FOREARM. |
| 08302005 | HOME | 71 | Male | Treated & Released | Lower Arm | GENERATOR EXPLODED, BURNED ARMS AND LEG. |

**Death Certificates (DTHS File)**
Date of Query: 12/7/2005
Date of Death: 01/01/1990 - 12/07/2005
Product code: 606
Narrative keyword: 'FIRE','FLAME','BURN'

| Document_No. | Date_of_Death | Age | Sex | Work_Related | Narrative |
|---|---|---|---|---|---|
| 9612031062 | 03111996 | 29 | Male | No | CLOTHING IGNITED WHILE WORKING WITH GASOLINE POWER GENERATOR - THERMAL BURNS TO 93% OF THE SKIN SURFACE - AUTOPSY YES |

Two records of this same death are in the IIPI file under document nos. N9630434A and X9673332A.

Narrative for IIPI document no. N9630434A reads: A 29YR OLD MALE DIED OF BURNS RECEIVED DURING A FIRE STARTED AS HE WAS REFUELING A GASOLINE POWERED GENERATOR. (Source: newsclip)

Narrative for IIPI document no. X9673332A reads: A 29 YEAR OLD MAN DIED IN A FIRE STARTED WHEN HE TRIED TO FILL GASOLINE IN HIS GENERATOR WHILE IT WAS TURNED OFF. (Source: MECAP)

**The Injury or Potential Injury Incident (IPII) File**
Date of Query: 12/7/2005
Incident Date: 01/01/1990 - 12/07/2005
Product code: 606
Narrative keyword: 'FIRE','FLAME','BURN'

| Date of Incident | State | City | Age | Sex | Disposition | Narrative |
|---|---|---|---|---|---|---|
| 11181990 | OH | PERRY TWP | NOT RECORDED | NOT RECORDED | NO INJURY | NO ONE WAS INJURED IN A HOUSE FIRE CAUSED BY A PORTABLE GENERATOR OVERHEATING ANI THE EXHAUST PIPE IGNITED INSULATION. |
| 03251991 | IN | KEMPTON | NOT RECORDED | NOT RECORDED | NO INJURY | NO ONE WAS INJURED IN A HOUSE FIRE STARTED WHEN THE CAP FELL OFF A PORTABLE GENERATOR AND GAS WAS IGNITED BY THE HOT ENGINE. |
| 11041991 | CA | SONORA | NOT RECORDED | NOT RECORDED | NO INJURY | AN ELECTRICAL SHORT IN A POWER GENERATOR STARTED A FIRE AT AN INN. |
| 02231992 | MD | COLUMBIA | NOT RECORDED | MALE | TREATED & RELEASED | A HOUSE FIRE BEGAN IN A PORTABLE GENERATOR. ONE FIREMAN WAS INJURED. |
| 12171992 | PA | PUNXSUTAWNEY | NOT RECORDED | NOT RECORDED | NO INJURY | A HOUSE FIRE WAS APPARENTLY CAUSED BY A GENERATOR. |
| 12181992 | CA | NAPPA | NOT RECORDED | NOT RECORDED | NO INJURY | A HOUSE FIRE STARTED DURING REFUELING OF A GAS POWERED ELECTRIC GENERATOR. |
| 03041993 | PA | COATESVILLE | NOT RECORDED | NOT RECORDED | NO INJURY | AN ELECTRIC GENERATOR CAUGHT FIRE IN A RESIDENTIAL HOME. |
| 06091993 | VA | LYNCHBURG | NOT RECORDED | NOT RECORDED | NO INJURY | A FIRE WAS APPARENTLY CAUSED BY AN OVERHEATING GENERATOR. |
| 07041993 | NY | EAST HAMPTON | NOT RECORDED | NOT RECORDED | NO INJURY | A HOUSE FIRE WAS APPARENTLY CAUSED BY A FAULTY GENERATOR. |
| 09131993 | CA | FEATHER FALL | NOT RECORDED | MALE | DOA | A MAN WAS KILLED IN A MOBILE HOME FIRE STARTED BY A GENERATOR OUTSIDE THE HOME, A 5( YEAR OLD FEMALE WAS INJURED. |
| 12031993 | HI | KAPAHI | NOT RECORDED | MALE | HOSPITALIZED | A MAN WAS BADLY BURNED WHEN GAS SPILLED WHILE FILLING A GENERATOR IN HIS HOME CAUSING AN EXPLOSION/FIRE. |
| 02241994 | MS | CLARKSDALE | NOT RECORDED | NOT RECORDED | NO INJURY | A HOUSE FIRE STARTED DURING REFUELING OF A GENERATOR THAT WAS RUNNING . |
| 04051994 | NY | SCHROON | NOT RECORDED | MALE | TREATED & RELEASED | A MALE WAS INJURED IN A HOUSE FIRE THAT STARTED IN THE BASEMENT NEAR THE GAS POWERED GENERATOR. |
| 04161994 | NE | CAMBRIDGE | NOT RECORDED | NOT RECORDED | NO INJURY | A HOUSE FIRE STARTED BECAUSE OF A GENERATOR USED DURING A POWER OUTAGE. |
| 05041994 | NE | OMAHA | NOT RECORDED | NOT RECORDED | NO INJURY | AN ELECTRICAL SHORT IN A GENERATOR'S CONNECTING WIRE IN A METAL SHED ADJACENT TO THE HOUSE CAUSED A FIRE. |
| 05131994 | WA | PORT ANGELES | NOT RECORDED | NOT RECORDED | NO INJURY | A FIRE WAS APPARENTLY IGNITED BY AN ELECTRICAL GENERATOR. |
| 07201994 | MI | BELMONT | NOT RECORDED | NOT RECORDED | NO INJURY | A HOUSE FIRE STARTED WHEN GAS SPILLED DURING FUELING OF A GENERATOR NEAR A NATURA GAS LINE. |
| 12131994 | NC | VANCE CO | NOT RECORDED | NOT RECORDED | NO INJURY | A FARM HOUSE FIRE STARTED WHEN A GAS GENERATOR EXPLODED. |
| 12151994 | MI | HOPKINS | 73 | MALE | DOA | A 73 YEAR OLD MALE DIED FOLLOWING A FIRE STARTED POURING GAS INTO A GENERATOR WHEN A LIGHT BULB BROKE. |
| 03101995 | ME | KNOY | NOT RECORDED | NOT RECORDED | NO INJURY | A MOBILE HOME FIRE WAS STARTED BY A GAS POWERED GENERATOR. |
| 05151995 | FL | PLAM BEACH | NOT RECORDED | NOT RECORDED | NO INJURY | A FAULTY VOLTAGE REGULATOR ON A GENERATOR SPARKED A HOUSE FIRE THAT DID $200,000 IN DAMAGE. NO INJURY. |
| 11121995 | CT | CANTERBURY | NOT RECORDED | MALE | TREATED & RELEASED | A MAN AND HIS WIFE WERE BOTH INJURED WHEN THE GENERATOR THEY WERE REFUELING NEAR A WOOD STOVE BLEW UP CAUSING A FIRE. |
| 09061996 | NC | TIMERLAKE | NOT RECORDED | NOT RECORDED | NO INJURY | A HOUSE FIRE WAS THE RESULT OF A GENERATOR MALFUNCTION. GENERATOR WAS USED DURING POWER OUTAGE FROM HURRICANE. NO INJURY. DAMAGE: $80,000. |
| 11021996 | NJ | MANTUA TWP | NOT RECORDED | NOT RECORDED | NO INJURY | GAS SPILLED ATOP AN OUTSIDE GENERATOR DURING REFUELING RESULTED IN A HOUSE FIRE. NO INJURY. DAMAGE: N/A. |
| 01161997 | TX | PORT ARTHUR | NOT RECORDED | NOT RECORDED | NO INJURY | FAULTY WIRING ON A GENERATOR CAUSED A HOUSE FIRE. NO INJURY. |
| 04251997 | KS | TOPEKA | NOT RECORDED | NOT RECORDED | NO INJURY | AN ELECTRICAL SHORT IN A GENERATOR IGNITED, BURNING THIS ARTIFICIAL POND'S WOODEN ORNAMENTAL DECK/ DOCK AT A LOCAL CONDO COMPLEX. DAMAGE: $35,000. NO INJURY. |
| 01121998 | NY | WALDEN | NOT RECORDED | NOT RECORDED | NO INJURY | AN EXPLODING GENERATOR RESULTED IN A STRUCTURE FIRE. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 07011998 | NY | NORTH HUDSON | NOT RECORDED | NOT RECORDED | NO INJURY | GASOLINE LEAKED FROM THE CAP OF A GENERATOR USED AT A SUMMER HOME DURING USE. CAP WAS REPLACED BY MANUFACTURER 3 TIMES AND THE SAME THING HAPPENED. NO INJURY, GAS INALATION, FIRE, AND EXPLOSION HAZARD. |
| 09261998 | PR | SAN JUAN | 15 | MALE | HOSPITALIZED | A BOY, AGE 15, AND HIS MOTHER, AGE 38, WERE BOTH SEVERELY BURNED AND HOSPITALIZED AFTER A GENERATOR BEING FILLED WITH GASOLINE IGNITED. |
| 03011999 | MD | OLNEY | NOT RECORDED | NOT RECORDED | NO INJURY | GASOLINE-POWERED GENERATOR LEAKED GASOLINE FROM FUEL TANK ONTO ITS ENGINE. FUEL TANK HAS A CRACK. NO INJURY, FIRE HAZARD. |
| 06111999 | IL | MOKENA | 52 | MALE | HOSPITALIZED | A MAN, AGE 52, WAS HOSPITALIZED FOR BURNS RECEIVED AFTER FUEL FROM A GAS GENERATOF IGNITED AT HIS HOME. |
| 08011999 | NY | ROSENDALE | NOT RECORDED | NOT RECORDED | NO INJURY | A STARTER MALFUNCTION ON A GENERATOR COULD RESULT IN OVERHEATING OR A FIRE. NO INJURY. |
| 11121999 | TN | BRISTOL | NOT RECORDED | NOT RECORDED | NO INJURY | A GAS POWERED GENERATOR WAS ON, WHEN GAS BEGAN TO SPILL FROM THE GAS CAP'S AIR HOLES. CONSUMER FEELS THAT THE GENERATOR HAS A DEFECTIVE MUFFLER CAUSING IT TO PUSH GAS THROUGH AIR HOLES AND POSES A FIRE HAZARD. NO INJURY. |
| 11231999 | UNK | UNK | NOT RECORDED | NOT RECORDED | NO INJURY | THE RUBBER FUEL LINE ON A GENERATOR CONTACTS AN EXHAUST BRACE DURING USE AND COULD RESULT IN A LEAK AND/OR FIRE. |
| 04252000 | CA | RICHMOND | NOT RECORDED | NOT RECORDED | NO INJURY | A FIRE WHICH DESTROYED A HOME WAS STARTED WHEN A CHILD ACCIDENTALLY KNOCKED OVEI A PORTABLE GAS GENERATOR. NO INJURIES OCCURRED. |
| 07012000 | VA | COLLINSVILLE | NOT RECORDED | NOT RECORDED | NO INJURY | SPARKS AND FLAMES BEGAN COMING FROM THE HOUSING COMPARTMENT OF A GASOLINE POWERED PORTABLE GENERATOR DURING USE. NO INJURY. |
| 08012000 | UT | LAVERKIN | NOT RECORDED | NOT RECORDED | NO INJURY | A PROPANE POWERED GENERATOR APPARENTLY LEAKED FUEL WHILE IT WAS IDLE. NO SET UP INSTRUCTIONS CAME WITH THE GENERATOR, WHICH CONVERTED FROM GASOLINE. NO INJURY. FIRE HAZARD. |
| 08072000 | VA | WILLIAMSBURG | NOT RECORDED | NOT RECORDED | NO INJURY | THE GASOLINE HOSE HAD UNFASTENED FROM ITS GAS TANK FROM THE GASOLINE POWERED GENERATOR, LEAKING GASOLINE ONTO THE CONCRETE GARAGE FLOOR AFTER IT HAD BEEN TURNED OFF FOR AN HOUR. NO INJURY. FIRE HAZARD. |
| 10012000 | MI | SOMERSET | NOT RECORDED | NOT RECORDED | NO INJURY | THE OWNER OF A NEW GENERATOR NOTICED THE GAS LEAKING FROM CARB, ON TO THE GROUND DURING USE. IT COULD CAUSE FIRE OR EXPLOSION. NO INJURY. |
| 10262000 | CT | PAWCATUCK | NOT RECORDED | NOT RECORDED | NO INJURY | A GENERATOR USED TO POWER A FLOOR SANDER WAS THE LIKELY SOURCE OF THE FIRE THAT MINOR DAMAGE TO A HOME. NO INJURY. |
| 12172000 | NY | HOWARD BEACH | 37 | MALE | TREATED & RELEASED | A MALE, AGE 37, HAND STUCK & MELTED TO A VERY HOT EXHAUST PIPE OF GENERATOR & RECEIVED SEVERE BURNS TO PALM OF RIGHT HAND & NERVE DAMAGE. GENERATOR PIPE IS NOT SHIELDED & THERE ARE NO LARGE WARNING SIGNS ON THE DEVICE. |
| 01012001 | SC | GAFFNEY | NOT RECORDED | NOT RECORDED | NO INJURY | THE FUEL TANK ON A GAS POWERED GENERATOR LEAKS WHERE A SCREW ATTACHES IT TO THE FRAME. NO INJURY, FIRE HAZARD. |
| 04262001 | FL | CRYSTALL RIVER | NOT RECORDED | NOT RECORDED | NO INJURY | GAS STARTED LEAKING WHEN A GENERATOR ENGINE WAS BEING TURNED "ON" FOR USE THE THIRD TIME. APPARENTLY PLASTIC FITTINGS HAD CAUSE A SPLIT IN THE GAS TANK. NO INJURY. FIRE HAZARD. |
| 05092001 | IL | OLLING MEADOW | NOT RECORDED | NOT RECORDED | NO INJURY | A SHORT CIRCUIT IN A GENERATOR CAUSED A FIRE AT AN ICE RINK. NO INJURY. DAMAGE: $10,000. |
| 07092001 | VA | BRISTOW | NOT RECORDED | NOT RECORDED | NO INJURY | AN OWNER TURNED ON POWER GENERATOR AFTER POWER WENT OUT. SURGE PROTECTORS BEGAN SMOKING AND A 2' FLAMES STARTED COMING FROM THE SURGE PROTECTOR. NO INJURY |
| 07242001 | DC | WASHINGTON | NOT RECORDED | MALE | HOSPITALIZED | ONE PERSON WAS HOSPITALIZED FOR BURNS IN AN APARTMENT FIRE. THE FIRE RESULTED AFTER A PERSON PUT GASOLINE IN AN EXTREMELY HOT GENERATOR. |
| 08202001 | WI | MONROE | NOT RECORDED | NOT RECORDED | NO INJURY | GENERATOR GAS TANK OPENED UP AT THE SEAM AND SPILLED 7 GALLONS OF GAS IN THE GARAGE. NO INJURY. FIRE HAZARD. |
| 08302001 | CA | LOS ANGELES | NOT RECORDED | NOT RECORDED | NO INJURY | TWO, THREE YEAR OLD GENERATORS PLASTIC FUEL TANKS MELTED CAUSING FUEL TO LEAK ONTO GENERATORS & HOT ENGINES. ALSO THE MELTED PLASTIC IN FUEL LINE CONGEALS IN UNITS. NO INJURY. FIRE HAZARD. |

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|---|---|---|---|---|---|---|
| 10012001 | GA | ATLANTA | NOT RECORDED | NOT RECORDED | NO INJURY | THE OWNER OF A GAS OPERATED GENERATOR REPORTS FINDING WIRES ARE RUBBED AGAINST SHEET METAL DURING USE. OWNER WAS INSTALLING WHEELS. NO INJURY, FIRE/ELECTRIC SHOCK HAZARD. |
| 11152001 | MI | STURGIS | NOT RECORDED | FEMALE | HOSPITALIZED | A WOMAN WAS SERIOUSLY BURNED WHILE TRYING TO REFILL THE GAS TANK ON A GENERATOR AND THE GAS IGNITED IN THE GARAGE OF HER HOME. SHE WAS HOSPITALIZED. THE FIRE DESTROYED TWO HOUSES. |
| 12122001 | VA | CHESTER | NOT RECORDED | NOT RECORDED | NO INJURY | RESPONDENT FEELS THAT THE GENERATORS POSE A FIRE HAZARD AS THEY ARE BEING SOLD WITHOUT THE ELECTRICAL CONNECTION, INSTRUCTION MANUAL. NO INJURY. |
| 01242002 | VA | RICHMOND | 17 | MALE | DOA | A MALE, AGE 17, DIED FROM THERMAL INJURIES & INHALATION OF COMBUSTION PRODUCTS SUSTAINED IN A FIRE INVOLVING GASOLINE & GENERATOR. TWO OTHER PEOPLE WERE ALSO INJURED. C0138485. |
| 01312002 | OH | MOUNT VERNON | NOT RECORDED | NOT RECORDED | NO INJURY | THE GENERATOR'S RUBBER PIECE THAT GOES INTO THE GAS TANK MELTED, CAUSING GASOLINE TO LEAK ONTO THE GARAGE FLOOR. NO INJURY. FIRE HAZARD. |
| 02012002 | NY | CLARKSON | 73 | MALE | DOA | A MAN, AGE 73, DIED OF SMOKE INHALATON IN A HOUSE FIRE. HE HAD BEEN TRYING TO START A GASOLINE GENERATOR IN THE GARAGE AT THE REAR OF THE HOUSE. |
| 02012002 | OH | BRYAN | NOT RECORDED | NOT RECORDED | NO INJURY | NO ONE WAS INJURED IN A HOUSE FIRE. THE CAUSE OF THE FIRE WAS FROM A GENERATOR BEING USED TO POWER THE SUMP PUMP AND THE REFRIGERATOR DUE TO THE POWER OUTAGE FROM ICE STORMS. DAMAGE: $200,000. |
| 02112002 | OK | TULSA | NOT RECORDED | MALE | TREATED & RELEASED | A MALE RESIDENT WAS REFILLING A GENERATOR WHEN THE GASOLINE FLASHED & CAUSED A FIRE IN THE GARAGE. HE RECEIVED 2ND DEGREE BURNS TO BOTH HIS LEGS. DAMAGE: $10,000. |
| 04282002 | NY | NORWICH | 16 | MALE | TREATED & RELEASED | A MALE, AGE 16, WAS FILLING A GAS OPERATED GENERATOR WHEN THE GAS IGNITED, CAUSING AN EXPLOSION & FIRE THAT DESTROYED A HOUSE. HE SUFFERED MINOR BURNS & TWO FIREFIGHTERS WERE ALSO INJURED. |
| 06292002 | CA | NAPA | NOT RECORDED | NOT RECORDED | NO INJURY | A WRECKING YARD FIRE STARTED WHEN A PORTABLE GENERATOR SHORTED & MAY HAVE RELEASED SPARKS THAT IGNITED A STORAGE CONTAINER. NO INJURY. |
| 07032002 | CT | N. STONINGTON | NOT RECORDED | NOT RECORDED | NO INJURY | NO ONE WAS INJURED WHEN A FIRE DESTROYED THE HOME. THE HOUSE HAD NO POWER LINES RUNNING TO IT, AND THE FAMILY USED A GENERATOR AND PROPANE FUEL. |
| 08042002 | LA | MORGAN | NOT RECORDED | MALE | NO INJURY | A HOUSE FIRE WAS STARTED WHILE A MALE HOMEOWNER WAS ATTEMPTING TO START A GENERATOR IN HIS GARAGE WHEN A SPARK IGNITED GASOLINE ON THE FLOOR. NO INJURY. |
| 09012002 | MI | CARO | NOT RECORDED | NOT RECORDED | NO INJURY | A GENERATOR WAS FOUND RUNNING AT HIGH RATE OF SPEED FOLLOWED BY THE BLACK SMOKE EXITING FROM THE MUFFLER. FUEL WAS STREAMING FROM THE AIR CLEANER BOX, POOLING A LARGE PUDDLE OF GASOLINE ON THE FLOOR UNDER THE GENERATOR. NO INJURED. POSES A FIRE HAZARD. |
| 09012002 | NY | CENTERPORT | NOT RECORDED | NOT RECORDED | NO INJURY | GAS TANK OF A GENERATOR LEAKED GAS ONTO THE ENGINE. FAULTY DESIGN OF THE GAS TANK & THE WAY IT WAS ATTACHED TO THE FRAME OF THE UNIT CAUSED A HOLE IN IT. NO INJURY. FIRE HAZARD. |
| 09302002 | MI | OTTAWA LAKE | NOT RECORDED | NOT RECORDED | NO INJURY | A WOMAN NOTICED A GAS ODOR AFTER HEARING A POPPING NOISE IN HER GARAGE. SHE DISCOVERED THAT THE GENERATOR'S CARBURETOR HAD RUST & WAS HANGING OFF OF THE GENERATOR. NO INJURY. POSES A FIRE HAZARD. |
| 10052002 | LA | VILLE PLATTE | NOT RECORDED | MALE | TREATED & RELEASED | GENERATOR EXPLODED WHILE OWNER WAS REFUELING IT & DESTROYED A HOME. A MALE SUFFERED ONLY MINOR BURNS. |
| 10092002 | CA | SANTA ROSA | 29 | FEMALE | TREATED & RELEASED | A FEMALE, AGE 29, WAS TRYING TO POUR GASOLINE INTO A GENERATOR WHEN IT BLEW UP. SHE SUFFERED 2ND DEGREE BURNS. DAMAGE: $10,000. |
| 10212002 | FL | GAINSVILLE | NOT RECORDED | NOT RECORDED | NO INJURY | PORTABLE GENERATOR STORED IN THE GARAGE FOR A LONG TIME LEAKED GASOLINE FROM THE SEAMS OF THE TANK. NO INJURY. FIRE HAZARD. |
| 11062002 | OH | WOOSTER | NOT RECORDED | NOT RECORDED | NO INJURY | WHILE USING AN ELECTRIC GENERATOR, GASOLINE LEAKED FROM THE SHUT OFF VALVE. THE PLASTIC SHUT OFF VALVE & THE RUBBER HOSE IS LOCATED ALMOST DIRECTLY OVER THE GENERATOR'S MUFFLER. NO INJURY. FIRE HAZARD. |

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| 12102002 | OH | JACKSON TWP. | NOT RECORDED | NOT RECORDED | NO INJURY | A HOUSE FIRE STARTED WHEN THE OWNER TRIED TO TURN OFF THE GENERATOR AND PUT GAS IN IT, THE MACHINE SPARKED. THE GENERATOR HAD A WHOLE TANK OF GAS AND CAUGHT ON FIRE. NO INJURY. |
| 12232002 | IL | SALEM | NOT RECORDED | MALE | TREATED & RELEASED | A MALE WAS INJURED WHEN HE WAS CHECKING ON A GENERATOR RUNNING INSIDE THE HOME WHEN A FLASH FIRE OCCURRED & STARTED A HOUSE FIRE. ANOTHER MALE SUFFERED A SEVERI CUT TO HIS HAND. |
| 01012003 | KS | OTTAWA | NOT RECORDED | NOT RECORDED | NO INJURY | WHILE USING A STANDBY GENERATOR DURING AN ICE STORM, OWNER NOTICED A BURNING SMELL & DISCOVERED THAT THE SURGE PROTECTOR CAUGHT ON FIRE. THE FLAMES SCORCHED THE FLOOR. NO INJURY. |
| 01012003 | PA | MT. PLEASANT | NOT RECORDED | NOT RECORDED | TREATED & RELEASED | A COUPLE DISCOVERED THAT THE GASOLINE OPERATED GENERATOR HAD BEEN LEAKING FUEL. CONSUMER FEELS THAT THE FUEL LEAK PRESENT A FIRE HAZARD. NO INJURIES OR PROPERTY DAMAGED. |
| 02182003 | OH | COOLVILLE | NOT RECORDED | NOT RECORDED | NO INJURY | FIRE APPEARED TO HAVE STARTED NEAR A NATURAL GAS GENERATOR & DESTROYED A TWO STORY HOME, GARAGE & OUTBUILDINGS. NO INJURY. |
| 02212003 | KY | GEORGETOWN | NOT RECORDED | NOT RECORDED | NO INJURY | A GENERATOR EXPLODED & STARTED A HOUSE FIRE. THE SMOKE DETECTORS IN THE HOME DID NOT OPERATE. NO INJURY. |
| 02272003 | NC | SEMORA | NOT RECORDED | NOT RECORDED | NO INJURY | DURING FIRST USE OF A PORTABLE GENERATOR, GASOLINE WAS NOTICED LEAKING FROM A SEAM IN THE TANK. NO INJURY, FIRE HAZARD. |
| 03012003 | NC | GREENSBORO | NOT RECORDED | NOT RECORDED | NO INJURY | A HOUSE FIRE IS BELIEVED TO HAVE BEEN STARTED WHEN A GASOLINE-POWERED GENERATOR WAS PLACED TOO CLOSE TO THE HOME. NO INJURY. DAMAGE: $30,000. |
| 03262003 | CA | SAN DIEGO | NOT RECORDED | NOT RECORDED | NO INJURY | A FIRE THAT DESTROYED A GARAGE CAUSED $125,000 DAMAGE. THE FIRE MAY HAVE BEEN CAUSED BY A GENERATOR. THE GENERATOR, WRAPPED IN INSULATION, WAS BEING USED BECAUSE UTILITES HAD BEEN SHUT OFF. NO INJURY. |
| 04012003 | WA | EVERETT | NOT RECORDED | NOT RECORDED | NO INJURY | THE FUEL TANK OF A PORTABLE GENERATOR WAS FOUND LEAKING. NO INJURY. POSES A FIRE HAZARD. |
| 06032003 | TN | GALLATIN | NOT RECORDED | NOT RECORDED | NO INJURY | ELECTRIC GENERATOR'S GAS TANK SEAM TURNED BRITTLE & CRACKED, ALLOWING GASOLINE TC DRIP ON MOTOR'S EXHAUST PIPE. NO INJURY. FIRE HAZARD. THE UNIT IS 4 YEARS OLD BUT HAS BEEN USED ONLY FOR 8 HOURS. |
| 06252003 | OR | BORING | NOT RECORDED | NOT RECORDED | NO INJURY | GENERATOR'S GAS TANK LEAKED GAS FROM THE VALVE. OWNER REPLACED THE VALVE 3 TIMES BUT THEY ALL BEGAN TO LEAK AFTER A SHORT TIME IT WAS USED. ON ONE OCCASION, THE GASOLINE WAS ON THE FLOOR NEAR A HOT WATER HEATER. NO INJURY. FIRE HAZARD. |
| 07022003 | NY | UTICA | NOT RECORDED | NOT RECORDED | NO INJURY | FIRE APPARENTLY STARTED NEAR A 2ND FLOOR PORCH & NEARLY DESTROYED A HOME & DAMAGED A NEIGHBORING HOME. THE OWNERS WERE PERFORMING REPAIRS WITH THE HELP OI A GENERATOR WHEN THE FIRE BEGAN. NO INJURY. |
| 07232003 | CO | FLORENCE | NOT RECORDED | NOT RECORDED | NO INJURY | A SPARKING GENERATOR APPARENTLY STARTED A FIRE THAT BURNED A GARAGE AND A SHED. NO ONE WAS INJURED. |
| 08052003 | WA | PORT ORCHARD | NOT RECORDED | NOT RECORDED | NO INJURY | GAS LINE CAME OUT OF THE GAS TANK OF A GENERATOR CAUSING GAS TO LEAK ON THE GENERATOR. NO INJURY. FIRE HAZARD. |
| 08142003 | MI | YPSILANTI | NOT RECORDED | MALE | TREATED & RELEASED | A CORD ATTACHED TO A GENERATOR THAT POWERED A TRAVEL TRAILER SHORTED OUT & STARTED A FIRE AT A FESTIVAL. THREE MEN SUFFERED SMOKE INHALATION & BURNS FROM MELTING PLASTIC. |
| 08162003 | MI | BIRMINGHAM | NOT RECORDED | NOT RECORDED | NO INJURY | GENERATOR EMITTED HIGH VOLTAGE DURING 1ST TIME USE. THIS RESULTED IN LIGHT BULBS, SWITCHES, RHEOSTATS & MOTORS TO SHORT, WIRES TO BURN & REFRIGERATOR TO MALFUNCTION. NO INJURY. FIRE HAZARD. |
| 08232003 | AR | MTN HOME | NOT RECORDED | NOT RECORDED | NO INJURY | OWNER TURNED GASOLINE SWITCH OFF TO EMPTY CARBURATOR WHEN GENERATOR LEAKED GASOLINE. IT SPILLED ONTO HOT MUFFLER & CAUSED A SMALL FIRE/ SMOKE THAT BURNED THE PLASTIC GAS TANK. HEAT SHIELD DOES NOT COVER GAS TANK WITH THE RETROFITTED MUFFLER. NO INJURY. |
| 09072003 | NY | OWN OF SENNET | NOT RECORDED | NOT RECORDED | NO INJURY | A HOUSE FIRE WAS CAUSED BY A GENERATOR. NO INJURY. |

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| 09262003 | VA | CHESPEAKE | NOT RECORDED | NOT RECORDED | NO INJURY | A BLUE FLAME AND UNUSUAL SOUND CAME FROM A GENERATOR DURING USE. NO INJURY. |
| 12252003 | ID | PRESTON | NOT RECORDED | NOT RECORDED | NO INJURY | NEW AIR COMPRESSOR WAS PLUGGED INTO ANOTHER GENERATOR WHEN IT CAUGHT FIRE, COMPLETELY MELTED & IGNITED THE CARPET. NO INJURY. |
| 01012004 | FL | ORANGE PARK | NOT RECORDED | NOT RECORDED | NO INJURY | NEW GENERATOR WAS USED FOR 12 HOURS A YEAR AGO & THEN STORED IN A GARAGE. OWNEF FOUND ITS FUEL LINE HAD A SIGNIFICANT AMOUNT OF CHAFING DUE TO VIBRATION DURING USE. UNIT POSES FIRE HAZARD AS ITS FUEL LINE RESTS AGAINST IT. NO INJURY. |
| 01292004 | AZ | SCOTTSDALE | NOT RECORDED | NOT RECORDED | NO INJURY | A GENERATOR MAY HAVE CAUSED A FIRE THAT DESTROYED A VENDOR TENT AT AN EQUESTRIAI CENTER. NO INJURY. |
| 01292004 | NE | BELLEVUE | NOT RECORDED | NOT RECORDED | NO INJURY | A MALE WAS WORKING ON A PORTABLE GENERATOR WHEN THE GAS TANK IGNITED & STARTED HOUSE FIRE. NO INJURY. |
| 03152004 | MI | BLOOMFIELD HILL | NOT RECORDED | NOT RECORDED | NO INJURY | GENERATOR WAS BEING TESTED WHEN THE EXHAUST PIPE OVERHEATED & IGNITED A WALL & CAUSED A HOUSE FIRE. NO INJURY. |
| 04022004 | UT | OGDEN | NOT RECORDED | NOT RECORDED | NO INJURY | DURING BACK UP GENERATOR USE, OWNER NOTICED SMOKE COMING FROM THE PRODUCTS THAT WERE PLUGGED IN AND TURNED TO THE ON POSITION. ALSO, LIGHTS WERE EITHER POPPING, BURNING BRIGHTLY & THEN TURNING TO THE OFF POSITION. NO INJURY. |
| 06302004 | LA | BATON ROUGE | NOT RECORDED | NOT RECORDED | NO INJURY | OWNER TOUCHED THE GASOLINE BLOCK VALVE ON THE GENERATOR TO DRAIN THE OLD GASOLINE WHEN THE WHOLE VALVE CAME OUT OF THE TANK, POURING GASOLINE ONTO THE GENERATOR. NO INJURY. FIRE HAZARD. |
| 08012004 | LA | SCOTANDVILLE | NOT RECORDED | NOT RECORDED | NO INJURY | FIRE THAT DESTROYED A HOME STARTED WHEN FUMES IGNITED FROM AN UNKNOWN SOURCE AFTER THE HOMEOWNER FILLED A GENERATOR WITH GASOLINE. NO INJURY. |
| 08022004 | AR | FAYETEVILLE | NOT RECORDED | NOT RECORDED | NO INJURY | GASOLINE TANK ATTACHED TO THE GENERATOR DRIPPED GASOLINE & EMITTED A GAS ODOR. NO INJURY. FIRE HAZARD. THE GENERATOR WAS IN OFF POSITION AT THE TIME OF THE INCIDENT. |
| 08182004 | FL | DAYTONA BEACH | NOT RECORDED | NOT RECORDED | NO INJURY | A PORTABLE GENERATOR STOPPED RUNNING WHILE IN USE. CONSUMER NOTICED THAT THE GAS WAS LEAKING FROM WHERE THE GENERATORS PETCOCK IS SECURED TO ITS GAS TANK. THE GAS WAS LEAKING ONTO THE GENERATOR'S ENGINE. NO INJURY. FIRE HAZARD. |
| 08252004 | FL | SARASOTA | NOT RECORDED | NOT RECORDED | NO INJURY | GASOLINE LEAKED FROM THE TANK DURING GENERATOR USE. OWNER FOUND A CRACK IN THE PLASTIC GASOLINE TANK. NO INJURY. FIRE HAZARD. |
| 09012004 | FL | ASTATULA | NOT RECORDED | NOT RECORDED | NO INJURY | WHILE FILLING GENERATOR'S GAS TANK, OWNER NOTICED THAT THE GAS TANK WAS LEAKING FROM ITS SEAMS. NO INJURY. FIRE HAZARD. |
| 09182004 | AL | MOBILE | NOT RECORDED | NOT RECORDED | NO INJURY | AN ELECTRIC GENERATOR STARTED A HOUSE FIRE THAT CAUSED SIGNIFICANT DAMAGES. NO INJURY. |
| 09272004 | FL | PORT ST. LUCIE | NOT RECORDED | NOT RECORDED | NO INJURY | GENERATOR'S OIL PLUG CAME LOOSE, LEAKED OIL & STARTED A HOUSE FIRE. NO INJURY. |
| 10302004 | PA | VESTABURG | NOT RECORDED | NOT RECORDED | NO INJURY | GENERATOR'S FUEL TANK LEAKED ON THE ENGINE SIDE FROM THE BOLT THAT HOLDS THE FUEL TANK TO THE FRAME. MANUAFCTURER HAS RECALLED ANOTHER BRAND FOR THE SAME PROBLEM. NO INJURY. FIRE HAZARD. |
| 11012004 | ID | SAGLE | NOT RECORDED | NOT RECORDED | NO INJURY | THE OWNER OF A GENERATOR REPORTS A FIRE AND SAFETY HAZARD WHEN THE GENERATOR IS USED TO POWER FLUORESCENT SHOP LIGHT BALLASTS. NO INJURY. |
| 11152004 | AL | ANNISTON | NOT RECORDED | NOT RECORDED | NO INJURY | GENERATOR'S GAS TANK IS LEAKING AT THE SEAMS. NO INJURY. FIRE HAZARD. |
| 11162004 | MI | LAPEER | NOT RECORDED | NOT RECORDED | NO INJURY | OWNER REPORTS GENERATOR'S SHUT OFF SWITCH BROKE. THE ONLY WAY TO TURN IT OFF WA EITHER TO PULL THE SPARK PLUG WIRE OFF OR LET IT RUN OUT OF GAS WHEN THE GAS TANK SPLIT, SPRAYING GAS IN A MIST. NO INJURY. FIRE HAZARD. |
| 11172004 | FL | UNK | NOT RECORDED | NOT RECORDED | NO INJURY | A FIRE INVOLVED A PORTABLE GENERATOR. NO INJURY. CLAIM # 8132656425. |
| 12302004 | TX | ENNESSEE COLON | NOT RECORDED | NOT RECORDED | NO INJURY | GASOLINE SPEWED FROM AN ELECTRIC GENERATOR'S VENT IN THE GAS CAP NEARLY EVERYTIM IT WAS IN USE. IF LEFT UNATTENDED, A FLASH FIRE COULD OCCUR. NO INJURY. FIRE HAZARD. |
| 01012005 | UNK | UNK | NOT RECORDED | NOT RECORDED | NO INJURY | PORTABLE GENERATOR'S GAS TANK WASN'T PROPERLY WELDED, CAUSING THE GAS TO LEAK FROM THE SEAMS. NO INJURY. POSES A FIRE OR EXPLOSION HAZARD. |

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| 05192005 | CA | CHICO | NOT RECORDED | NOT RECORDED | NO INJURY | NO ONE WAS INJURED IN AN UNOCCUPIED HOUSE FIRE THAT WAS BEING RENOVATED. THE CAUSE OF THE FIRE WAS A GENERATOR THAT THE MAN, WHO WAS WORKING ON THE HOME, HAD BEEN USING. DAMAGE: $100,000. |
| 05192005 | CA | DURHAM | NOT RECORDED | NOT RECORDED | NO INJURY | NO ONE WAS INJURED IN A SMALL, VACANT HOUSE FIRE. A GENERATOR BEING USED TO SUPPLY POWER TO THE DWELLING IS MOST LIKE CAUSE OF THE BLAZE. |
| 07102005 | AL | THEODORE | NOT RECORDED | NOT RECORDED | NO INJURY | PORTABLE GENERATOR'S GAS TANK HAS CRACKS & IS LEAKING. NO INJURIES. FIRE HAZARD. |
| 07252005 | LA | UNKNONW | NOT RECORDED | NOT RECORDED | NO INJURY | THIS TRADE COMPLAINT REPORTS THAT GENERATORS ARE DESIGNED TO BE COMPACT. THE ELECTRICAL CONNECTION IS MOLDED IN THE MIDDLE OF THE UNIT'S PLASTIC GAS TANK & THE ENGINE GETS EXTREMELY HOT CAUSING THE FUEL TANK TO MELT. NO INJURY. FIRE HAZARD. |
| 07272005 | MI | ROCHESTER HILLS | NOT RECORDED | NOT RECORDED | NO INJURY | A FAULTY GENERATOR PLUGGED INTO AN OUTLET DESTROYED ALL THE ELECTRONICS THAT WERE ON THAT LINE. THE GENERATOR OUTPUT 159 VOLTS INSTEAD OF OUTPUTTING 230 VOLTS NO INJURY. FIRE HAZARD. |
| 08252005 | FL | CAPE CORAL | 42 | MALE | DOA | A MALE, AGE 42, WAS ATTEMPTING TO REFILL A GASOLINE GENERATOR THAT WAS OPERATING WHEN GASOLINE IGNITED. CAUSE OF DEATH THERMAL INJURIES SUSTAINED IN THE FIRE. 05-5106. |
| 08302005 | LA | VACHERIE | 85 | MALE | NO INJURY | CONSUMER REPORTS THAT GENERATOR IS LEAKING GASOLINE FROM SEAM ON TANK. NO INJURY FIRE HAZARD. |
| 09042005 | MS | LAUREL | NOT RECORDED | NOT RECORDED | NO INJURY | A MOBILE HOME FIRE WAS STARTED BY A GENERATOR THAT WAS USED TO PROVIDE POWER TO THE HOME. NO INJURY. |
| 09182005 | FL | OCOEE | NOT RECORDED | NOT RECORDED | NO INJURY | A BRAND NEW GENERATOR STARTED LEAKING GASOLINE FROM BETWEEN THE TANK & THE FUE CUT OFF VALVE INTO OWNER'S GARAGE. NO INJURY. FIRE HAZARD. |
| 09212005 | CA | ELK GROVE | NOT RECORDED | NOT RECORDED | NO INJURY | OWNER TRIED TO START THE GENERATOR WHEN THE SHUT OFF VALVE & FILTER SCREEN LOCATED AT THE BOTTOM OF THE PLASTIC FUEL TANK FELL OUT CAUSING FUEL TO BE RELEASE ONTO THE UNIT'S BODY. NO INJURY. FIRE HAZARD. |
| 09242005 | LA | PELICAN | NOT RECORDED | NOT RECORDED | NO INJURY | OWNER OF A PORTABLE GENERATOR NOTICED THAT FUEL IS LEAKING FROM THE SEAMS OF THE TANK WHEN HE FUELED THE GENERATOR FOR THE FIRST TIME. NO INJURY. FIRE HAZARD. |
| 09282005 | AZ | PHOENIX | NOT RECORDED | NOT RECORDED | NO INJURY | NO ONE WAS INJURED IN A HOUSE FIRE. THE FIRE STARTED IN A GAS GENERATOR IN A SHED AN SPREAD TO THE HOME. DAMAGE: $20,000. |
| 09282005 | TX | WILLIS | NOT RECORDED | NOT RECORDED | NO INJURY | A HOME WAS DESTROYED WHEN A GENERATOR RUNNING ON THE BACK PORCH STARTED A FIRE THE CAUSE OF THE FIRE IS BELIEVED TO BE A MALFUNCTIONING GENERATOR. NO INJURY. |
| 10012005 | NC | WILMINGTON | NOT RECORDED | NOT RECORDED | NO INJURY | OWNER OF A GENERATOR REPORTS THAT GASOLINE IS LEAKING FROM AROUND THE SEAM OF THE FUEL TANK WHERE IT SITS ON THE FRAME JUST OVER & BEHIND THE MUFFLER. NO INJURY. FIRE HAZARD. |
| 10252005 | FL | GOODLAND | NOT RECORDED | NOT RECORDED | NO INJURY | A GENERATOR STARTED A FIRE THAT DESTROYED A HOME. NO INJURY. |
| 10262005 | FL | STUART | 76 | MALE | NO INJURY | A HOUSE FIRE WAS CAUSED BY A GENERATOR USED TO POWER UP A HOUSE. THE GENERATOR SAT OUTSIDE BESIDE THE HOUSE. NO INJURY. |
| 11012005 | FL | MIAMI | 7 | MALE | TREATED & RELEASED | TWO BROTHERS, AGES 17 & 7, SUFFERED MINOR INJURIES WHEN A GENERATOR CAUGHT FIRE A THE TEEN WAS TRYING TO START IT. HE WAS PUTTING GASOLINE INTO THE GENERATOR WHEN BURST INTO FLAMES. THE FIRE CAUSED EXTENSIVE DAMAGE TO THE HOME. |
| 11072005 | MI | IDEPENDENCE TW | NOT RECORDED | NOT RECORDED | NO INJURY | A GAS POWERED GENERATOR, LOCATED IN A WOODEN BOX NEAR THE HOME CAUGHT FIRE & STARTED A HOUSE FIRE. THE GENERATOR WAS BEING USED DURING A POWER OUTAGE. NO INJURY. |

**The In-Depth Investigation (INDP) File**
Date of Query: 12/7/2005
Incident Date: 01/01/1990 - 12/07/2005
Product code: 606
Narrative keyword: 'FIRE','FLAME','BURN'

| Date of Accident | State | City | Sex | Age | Disposition | Location | Narrative |
|---|---|---|---|---|---|---|---|
| 04011992 | CA | YUBA CITY | Male | Not Recorded | No Injury | Home | A FOUR YEAR OLD METAL GASOLINE TANK FOR AN ELECTRIC GENERATOR DEVELOPED STRESS CRACKS AND LEAKED FUEL. NO FIRE OR INJURY OCCURRED. |
| 03111994 | OH | CHILLICOTHE | Male | 25 | Treated & Released | Home | A FIRE OCCURRED WHEN TWO MEN ATTEMPTED TO USE A ELECTRIC GENERATOR TO PROVIDE POWER TO THEIR HOME DURING A POWER OUTAGE. A LEAKING CAN CONTAINING GASOLINE WAS THE CAUSE OF THE FIRE. BOTH MEN RECEIVED BURNS TO THEIR HANDS. |
| 06151994 | KS | COLBY | Not Recorded | 35 | No Injury | Farm | A CONSUMER COMPLAINT BY AN AG ENGINEER AT THE KSU EXPERIMENT STATION REPORTED THAT A PORTABLE ELECTRIC GENERATOR WAS A POTENTIAL FIRE HAZARD. THIS MODEL GENERATOR HAS THE GASOLINE TANK ON TOP OF THE GENERATOR ENGINE. RAW GAS LEAKED SEVERAL TIMES ONTO THE HOT ENGINE. |
| 11241995 | CA | SAN BERNARDIN | Male | 13 | Death | Home | A 13 YEAR OLD BOY AND HIS 7 YEAR OLD SISTER WERE TOGETHER IN THEIR HOME. THEY WERE OPERATING A GASOLINE POWERED ELECTRICAL GENERATOR.THEIR HOME HAD NO ELECTRICITY. THEY NEEDED POWER FOR HEAT. THE BOY WAS POURING GASOLINE INTO THE RUNING GENERATOR. THE GASOLINE IGNITED. BOTH CHILDREN RECIEVED BURNS AND WERE HOSPITALIZED. THEY DIED FROM COMPLICATIONS OF THE BURNS. |
| 08281998 | NC | SNEADS FERRY | Not Recorded | Not Recorded | No Injury | Home | THIS INVESTIGATION INVOLVED A GASOLINE POWERED ELECTRIC GENERATOR.THE COMPLAINANT PURCHASED THE GENERATOR IN SEPT. OF 1997. THE GENERATOR WAS PERIODICALLY CHECKED AND USED ONCE FOR AN 8 HOUR PERIOD OF TIME. THE FOLLOWING DAY THE COMPLAINANT DISCOVERED THE GAS TANK HAD LEAKED APPROXIMATELY 3 GALLONS OF GAS. NO FIRE OR INJURIES OCCURRED. |
| 10031998 | PR | LAS PIEDRAS | Male | 38 | Treated & Released | Home | A FIRE APPARENTLY CAUSED BY OVERLOAD FROM A GASOLINE-FUELED PORTABLE ELECTRICAL GENERATOR CAUSED INJURIES TO FOUR FAMILY MEMBERS IN THEIR HOUSE. A 38 YEAR OLD MALE AND HIS 38 YEAR OLD WIFE RECEIVED 1ST DEGREE/2ND DEGREE THERMAL BURNS AND THEIR 15-YEAR OLD SON RECEIVED 2ND DEGREE THERMAL BURNS AND THEIR 4 YEAR OLD SON SUFFERED SMOKE INHALATION. ALL WERE TREATED AND RELEASED AT A NON-NEISS HOSPITAL. |
| 06041999 | MI | BELMONT | Male | 42 | No Injury | Home | A HOMEOWNER SUSTAINED $150 IN PROPERTY DAMAGE TO HIS BASEMENT WALL, DUE TO A FIRE, THAT WAS CAUSED BY A MAL-ADJUSTED GASOLINE GENERATOR AND A SURGE PROTECTOR. THE GENERATOR WAS ADJUSTED AND IS WORKING FINE. THE SURGE PROTECTOR COULD NOT BE IDENTIFIED OR SAMPLED. |
| 12301999 | MN | DULUTH | Male | 52 | Hospitalized | Home | A DULUTH, MN MALE WAS ATTEMPTING TO START AN ELECTRIC GENERATOR IN THE BASEMENT OF HIS HOME. INDIVIDUAL PULLED ON THE STARTER CORD A THIRD TIME AND AN EXPLOSION OCCURRED. FIRE DEPARTMENT RESPONDED AND PUT OUT THE FIRE. DAMAGE $60,000. VICTIM WAS TAKEN TO THE HOSPITAL.HE HAS BURNED LUNGS AND SUFFERED 1ST DEGREE BURNS TO HAND FROM MELTING CAN. |

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| 02032002 | KS | LOUISBURG | Male | Not Recorded | No Injury | Home | THE COMPLAINANT'S POWER HAD BEEN OUT FOR SEVERAL DAYS DUE TO AN ICESTORM. HE BORROWED A GENERATOR FROM A NEIGHBOR AND HOOKED IT UP.AFTER STARTING THE GENERATOR HE WATCHED THE DIAL AS THE UNIT RANSTEADY AT 220 VOLTS. IT THEN SUDDENLY SURGED TO 300 FOR A COUPLE OFSECONDS. HIS WIFE YELLED AT HIM THAT SOMETHING WAS BURNING AND HE TURNED THE GENERATOR OFF. SEVERAL ITEMS IN HIS HOME WERE RUINED DUE TO THE POWER SURGE. A COUPLE OF DAYS LATER HIS DAUGHTER FOUND THE DAMAGED SURGE PROTECTOR WHICH WAS LOCATED IN THE GARAGE. |
| 09012002 | KY | MORNING VIEW | Not Recorded | Not Recorded | No Injury | Home | THE SHUT OFF VALVE ON THE COMPLAINANT'S THREE-YEAR-OLD PORTABLE,GASOLINE ENGINE-POWERED ELECTRIC GENERATOR DRIPS RAW GASOLINE DIRECTLY ONTO THE HOT ENGINE WHEN IN THE OPEN POSITION. THECOMPLAINANT FEELS THAT THIS IS A VERY DANGEROUS CONDITION THAT COULD LEAD TO FIRE OR EXPLOSION. THERE WERE NO INJURIES. |
| 07092003 | PA | PITTSBURGH | Not Recorded | Not Recorded | No Injury | Home | A GASOLINE POWERED GENERATOR WAS BEING USED TO POWER FIVE ITEMS IN A HOUSEHOLD AFTER A POWER OUTAGE. AFTER FOUR HOURS OF USE, THE HOMEOWNER WAS REFILLING THE FUEL TANK WHEN HE NOTICED THE FUEL WAS LEAKING OUT OF THE SIDE OF THE FUEL TANK. THE FUEL TANK HAD MELTED FROM THE HEAT OF THE GENERATOR'S ENGINE. THE HOMEOWNER SHUT OFF THEGENERATOR AND PREVENTED A FIRE SITUATION. NO INJURIES OR PROPERTY DAMAGE RESULTED FROM THIS INCIDENT. |
| 08152003 | MI | WATERFORD | Male | Not Recorded | No Injury | Home | A GAS POWERED GENERATOR CAUSED A GARAGE FIRE THAT SPREAD TO A HOUSE.DUE TO A POWER OUTAGE, THE HOMEOWNER HAD A GENERATOR IN HIS GARAGE, RUNNING ALL NIGHT AND LEFT TO GET SOME MORE GASOLINE. UPON HIS RETURN, THE GARAGE AND HOUSE WERE IN FLAMES. OFFICIALS CONCLUDED THAT THE ORIGIN OF THE FIRE WAS WHERE THE GENERATOR WAS LOCATED AND THE HEAT AND IGNITION SOURCE WAS CAUSED BY THE EXHAUST SYSTEM COMING OFF THE GENERATOR. PROPERTY AND CONTENTS LOSS WAS VALUED AT $204,000. THE HOME DID HAVE WORKING OPERATING SMOKE DETECTORS. NO INJURIES WERE SUSTAINED. |
| 09012003 | OH | CHARDON | Not Recorded | Not Recorded | No Injury | Home | DURING A POWER FAILURE, THE COMPLAINANT HAD BEEN USING HIS PORTABLE GAS GENERATOR FOR A FEW HOURS. HE WENT TO CHECK ON IT AND FOUND THAT GAS WAS SEEPING FROM A SEAM IN THE GAS TANK THAT IS JUST ABOVE THE ENGINE. HE FEELS THAT THIS PRESENTS A FIRE AND EXPLOSION HAZARD. |
| 08122004 | FL | YBOR CITY | Female | 50 | No Injury | Home | A 50-YEAR-OLD FEMALE STARTED A PORTABLE GENERATOR IN HER GARAGE/LAUNDRY ROOM AND NOTICED IT WAS LEAKING. SHE PUT A PAN UNDER THE GENERATOR TO COLLECT THE LEAKING GASOLINE. THE FUMES FROM THE GASOLINE REACHED THE PILOT LIGHT ON HER NATURAL GAS WATER HEATER AND IGNITED. FIRE SPREAD THROUGHOUT THE GARAGE/LAUNDRY AND PART OF THE HOUSE. ONE FIREFIGHTER RECEIVED MINOR INJURIES. NO ONE ELSE WAS INJURED. ESTIMATED DAMAGE TO HOUSE AND CONTENTS WAS SHOWN AS $70,000. |

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| 08172004 | FL | DAYTONA BEACH | Male | 42 | Hospitalized | Public | THE 42-YEAR-OLD MALE VICTIM STATES THAT HE PLACED A NEW 5000 WATT GASOLINE GENERATOR IN THE STORAGE ROOM OF HIS RESTAURANT TO POWER TWO REFRIGERATORS TO PREVENT FOOD FROM SPOILING DURING A POWER OUTAGE CAUSED BY A HURRICANE. HE STATES THAT HE LEFT THE GENERATOR RUNNING OVERNIGHT AND THE FOLLOWING MORNING AFTER HE REFUELED IT, THE FUEL LINE BEGAN LEAKING AT THE BOTTOM OF THE TANK AND THEN DISCONNECTED, SPILLING FUEL ONTO THE FLOOR WHICH IGNITED, SEVERELY BURNING HIS LEGS: THE RESULTING FIRE CAUSED APPROXIMATELY $10,000 INDAMAGE. THE VICTIM WAS ADMITTED TO THE BURN UNIT OF A HOSPITAL FOR TREATMENT FOR APPROXIMATELY ONE MONTH. |
| 08182004 | FL | ORLANDO | Female | 30 | No Injury | Home | A 30-YEAR OLD FEMALE TURNED ON A PORTABLE GENERATOR AND PLUGGED IN TWO EXTENSION CORDS (ONE TO A REFRIGERATOR AND ONE TO A BOX FAN) AFTER HER ELECTRICITY WENT OUT. APPROXIMATELY 15 MINUTES AFTER SHE TURNED THE GENERATOR ON, THE GASOLINE TANK EXPLODED AND THE GENERATOR CAUGHT FIRE. NO ONE WAS INJURED. THE GENERATOR WAS DESTROYED AND FIRE DAMAGE WAS LIMITED TO THE EAVES OF THE ROOF IN THE BACK OF THE HOUSE, AND A DOUBLE-PANE WINDOW THAT WAS SHATTERED. |
| 10262004 | IL | ROCKFORD | Female | 43 | No Injury | Home | A PORTABLE GAS GENERATOR CAUGHT ON FIRE. THE FIRE IGNITED THE BACKPART OF THE HOUSE. THE COMPLAINANTS WERE USING THE PORTABLE GAS GENERATOR FOR POWER BECAUSE THE GAS AND ELECTRICITY TO THEIR HOUSE HAD BEEN SHUT OFF. NO ONE WAS INJURED. PROPERTY DAMAGE TO THE HOUSE WAS $20,000. SMOKE DETECTORS WERE PRESENT AND DID ALARM. |
| 10272004 | NC | PFAFFTOWN | Male | 24 | Hospitalized | School | A 24-YEAR OLD MALE WAS SEVERELY BURNED AT WORK WHILE ATTEMPTING TO START A GAS-POWERED GENERATOR INSIDE THE DOORWAY OF A STORAGE TRAILER (OPEN DOORS). THE FUEL TANK LEAKED GASOLINE OVERNIGHT AND THE TRAILER WAS FILLED WITH FUMES. THE VICTIM YANKED ON THE PULL CORD AND A SPARK IGNITED THE FUMES. HE WAS HOSPITALIZED; ESTIMATED DAMAGES WERE $6,000. |
| 11262004 | IL | BLOOMINGTON TO\ | Male | 83 | No Injury | Home | A GASOLINE 4000 WATT, 1 GALLON TANK GENERATOR AND/OR AN EXTENSION CORD MAY HAVE BEEN RESPONSIBLE FOR A RESIDENTIAL FIRE. THEY WERE PURCHASED USED ABOUT 5 YEARS AGO. THERE WERE NO INJURIES. THERE WERE NO SMOKE DETECTORS IN THE RESIDENCE. THE CIRCUIT BREAKER HAD BEEN ALTERED BY THE RESIDENCE OWNER. IT IS NOT KNOWN IF THE CIRCUIT BREAKER TRIPPED. |
| 12012004 | OH | GRANVILLE | Male | 75 | No Injury | Home | CONSUMERS SAW A FLAME EMERGE FROM THEIR POWER SURGE PROTECTOR. THE FLAME SELF-EXTINGUISHED. NO INJURIES SUSTAINED. THE EXTENT OF DAMAGEWAS CONFINED TO THE SURGE PROTECTOR, POWER CORDS OF THE ELECTRONIC EQUIPMENT, AND CARPET AND WALL WHICH WERE SLIGHTLY SCORCHED. ESTIMATED CONTENT LOSS WAS $710. THE CONSUMERS HAVE TWO CIRCUIT PANEL BOXES IN THE HOME BUT DO NOT RECALL ANY OF THE CIRCUIT BREAKERS TRIPPING. SMOKE DETECTORS DID NOT SOUND. AN AUTOMATIC SPRINKLER SYSTEM WAS NOT PRESENT. THERE WERE A COUPLE OF FIRE EXTINGUISHERS IN THE HOME. THEY WERE PLUGGED INTO A GENERATOR. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 01062005 | IN | CARMEL | Male | 55 | No Injury | Home | RESIDENTIAL FIRE RESULTING IN APPROXIMATELY $200,000 PROPERTY DAMAGES WAS STARTED BY A PORTABLE GENERATOR THAT WAS PLACED TOO CLOSE TO COMBUSTIBLE MATERIAL (PLYWOOD PANELING) INSIDE GARAGE. NO INJURIES RESULTED. SMOKE DETECTORS WERE PRESENT AND DID ALARM. |
| 01152005 | OR | CROOKED RIVER R/ | Male | 60 | Treated & Released | Home | A 60 YEAR OLD MALE RENTED A PORTABLE GAS GENERATOR TO PROVIDE POWER TO ITEMS IN HIS MANUFACTURED HOME WHEN THE ELECTRICITY WENT OUT. HE PLACED THE PORTABLE GAS GENERATOR OUTSIDE ON A CEMENT PAD NEAR HIS RENTED MANUFACTURED HOME. HE RAN TWO EXTENSION CORDS FROM THE GENERATOR INTO THE HOME TO PROVIDE POWER FOR A REFRIGERATOR, PORTABLE HEATER AND A SALT WATER AQUARIUM. HE PLACED GAS IN THE GENERATOR AND LEFT FOR TWO AND HALF HOURS. HE RETURNED HOME AND ATTEMPTED TO REFUEL THE GENERATOR. HIS HANDS SLIPPED WHILE HOLDINGTHE GAS CAN. GAS SPILLED ONTO THE WARM MUFFLER OF THE GENERATOR AND CAUGHT FIRE. HIS WIFE CALLED 911. THE FIRE DEPARTMENT ARRIVED AND EXTINGUISHED THE FIRE. HE WAS NOT INJURED. |
| 02022005 | WA | BOTHELL | Male | Not Recorded | No Injury | Home | HOUSE FIRE STARTED BY THE HEAT FROM THE EXHAUST OF A PORTABLE GAS POWERED GENERATOR GETTING TOO NEAR COMBUSTIBLES. NO INJURIES.$364,000 IN DAMAGE DONE TO HOUSE AND CONTENTS. NO INFORMATION ON MAKE AND MODEL OF GENERATOR OR SMOKE ALARMS THAT WERE PRESENT. |
| 04252005 | FL | WEST PALM BEACH | Male | 20 | Hospitalized | Home | A TWENTY YEAR OLD MALE TEMPORARILY RESIDING IN A STRUCTURE SCHEDULED FOR DEMOLITION SUFFERED SMOKE INHALATION REQUIRING TREATMENT AT A LOCAL HOSPITAL WHEN A FIRE OCCURRED. THE CAUSE OF THE FIRE WAS LISTED AS AN UNSPECIFIED MALFUNCTION IN A PORTABLE GENERATOR BEING USED TO PROVIDE ELECTRICITY TO THE STRUCTURE. DAMAGE TO THESTRUCTURE WAS TOTAL AND ESTIMATED AT $50,000. THE GENERATOR WAS TOO BADLY DAMAGED TO DETERMINE AN EXACT CAUSE OF THE MALFUNCTION. |
| 08282005 | FL | FT. LAUDERDALE | Male | 60 | No Injury | Home | THIS 60 YEAR OLD MALE BUILT HIS CUSTOM HOME IN 1999 AND INSTALLED A NATURAL GAS 6000 WATT GENERATOR WHICH HAD NEVER BEEN USED UNTIL THIS INCIDENT. IT WAS LOCATED IN A OPEN CARPORT WHICH HAD A FABRIC HURRICANE BARRIER. THE NEIGHBOR SMELLED SMOKE AND SAW A 3 FOOT GAS FLAME SHOOTING OUT FROM THE WALL. THERE WERE NO INJURIES. DAMAGES TO THE HOME WERE $20,000 AND $20,000 IN CONTENTS. |

# TAB F

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

**Memorandum**

**Date:** September 21, 2004

**TO:** Janet Buyer, Project Manager, Engine-Driven Tools,
Division of Combustion and Fire Sciences, Directorate for Engineering Sciences

**Through:** Mary Ann Danello, Ph.D., Associate Executive Director,
Directorate for Health Sciences (HS)
Lori E. Saltzman, M.S., Division Director, HS

**FROM:** Sandra E. Inkster, Ph.D., Pharmacologist, HS

**SUBJECT:** Health hazard assessment of CO poisoning associated with emissions from a portable, 5.5 kilowatt, gasoline-powered generator.

**Outline**

This memorandum presents (1) an overview of the CO poisoning hazard associated with consumer products, with emphasis on generator-related concerns, and (2) a preliminary health hazard assessment of the CO poisoning severity that can be expected if a 5.5 kilowatt gasoline-powered generator is operated in the basement of a hypothetical single family home.

**Background**

The U.S. Consumer Product Safety Commission (CPSC) has long been concerned with the problem of accidental, non-fire related carbon monoxide (CO) poisoning associated with consumer products. Reducing the rate of unintentional CO poisoning deaths associated with consumer products is a strategic goal of the agency. Staff employs a multi-faceted approach to combat CO poisoning, including working with relevant standards authorities and industry to improve source product performance standards, undertaking consumer information and education campaigns, and encouraging the development and use of secondary intervention devices (i.e., residential CO alarms). In addition, the staff actively tracks and investigates CO poisoning incidents and issues an annual report on the estimated number of CO poisoning deaths associated with consumer products. These efforts have contributed to a reduction in consumer product-related CO poisoning deaths in past years. CPSC and other interested parties have endeavored to promote consumer awareness of the fact that commonly used residential combustion products (e.g., furnaces, space heaters, and ranges) can generate hazardous CO exposures under certain circumstances. Though typically, such products are designed to produce relatively low levels of CO when operating normally, CO deaths are known to have resulted when the products have generated high levels of CO due to either improper installation, poor maintenance, inappropriate use, and/or compromised ventilation systems.

In the mid 1990s, CPSC staff collaborated with several other safety agencies to produce a joint safety alert highlighting the CO poisoning hazard associated with use of small gasoline-powered engines and tools (NIOSH, 1996, Pub. No 96-118). The National Institute of Occupational Safety and Health (NIOSH) was the lead agency coordinating this initiative, reflecting the fact that, at that time, a large number of known victims were using the products (e.g., pressure washers, concrete cutters, compressors, generators, etc) in occupational settings. Important findings noted in the safety alert were a lack of awareness of the CO hazard among the user population, and the fact that some users were aware that ventilation was needed, but frequently underestimated exactly what constituted adequate ventilation. The safety alert recommended that tool manufacturers and rental companies put targeted warning labels on the products with suggested wording "carbon monoxide produced during use can kill, do not use indoors or in other sheltered areas." Though helpful to consumers, the safety alert was aimed at the worker population.

During the late 1990s, there was some concern that the advent of the new millenium ("Y2K") might result in widespread computer failures and associated power outages. In response, consumer sales of portable, light duty gasoline-powered generators increased. These products are widely available to consumers at most home-improvement stores (Donaldson, 2004). Current environmental CO emissions control requirements, applicable to engine classes that include most portable, gasoline-powered, generator-type engines, allow exhaust to contain high levels of CO when operating normally (519 to 610 g/kW-hr)[1]. Although the Y2K fears of widespread computer failure and power outages were not realized, CPSC staff had serious concerns that increased consumer use of generators could result in an increase in CO poisoning deaths and injuries. In FY 2002, CPSC staff started a new project specifically intended to address CO poisonings involving the product category of small engine-driven tools.

The most recent data report from CPSC's Directorate for Epidemiology, Division of Hazard Analysis (Carlson, 2004) notes that CPSC staff is aware of 258 CO-poisoning fatalities involving various types of engine-driven tools that occurred between January 1, 1990 and December 31, 2003, and which were reported to CPSC as of March 1, 2004. Generators account for the majority of cases, being associated with 228 deaths (88%). It should be noted that, in 1999, the 10th revision of the International Classification of Disease (ICD-10) became effective, resulting in changes in the classification of CO-related deaths. Prior to 1999, CPSC did not routinely collect death certificates associated with engine-driven tools. Since 1999, CPSC has collected death certificates associated with all CO poisonings. The changes could affect the number of CO poisoning deaths reported to CPSC. For the period January 1, 1999 through December 31, 2003, CPSC received 120 report of CO deaths associated with use of generators versus 16 reports for all other engine-driven tools. The reporting of CO deaths to CPSC for recent years is not complete and so actual death counts can possibly increase.

Portable gasoline-powered generators account for an increasing majority of deaths reported for the small engine-driven tool category, and therefore, are the primary focus of the CPSC's "Small engine-driven tools" project. Recent project activities have included laboratory tests of generators in controlled settings, in order to characterize the CO poisoning hazard associated with exposure to CO-laden combustion emissions.

[1] In 1992, to address outdoor pollution concerns, the U.S. Environmental Protection Agency (EPA) began to develop emissions standards applicable to new non-road spark-ignition nonhandheld engines, at or below 19 kW; these requirements apply to CO (completed), hydrocarbons and nitrogen oxides (still being phased in) (40 C.F.R part 90).

**Common Scenarios Associated with Fatal, Generator-Related CO Poisonings**

The previously mentioned Directorate for Epidemiology staff memorandum (Carlson, 2004) reports that 138 of the 228 total generator-related deaths have been the subject of 102 in-depth investigations (IDIs) conducted by CPSC staff. Data are not complete for all cases, but the anecdotal information obtained from analysis of the IDIs has identified some common features of fatal generator incident scenarios.

Most in-depth investigations of incidents that occurred at the home were associated with the use of generators in basements or crawlspaces, in garages or enclosed car-ports, or inside a living space. The generators were commonly used as an emergency power source for a fixed home, or as a power source for a temporary location such as a motor home, trailer, camper, or boat. In several of these reports, it was noted that a door or window had been left open, possibly to provide ventilation. In two unrelated deaths that were investigated, the generator had been placed outdoors; however, it was located too close to an open window, or to the home's air intake, which allowed lethal levels of CO in the exhaust to infiltrate the living space. Most fatal incidents reported only one fatality – typically an adult victim over 24 years of age, who was usually male. However, numerous fatal incidents involved simultaneous exposure of one or more additional victims, many of whom survived various degrees of CO poisoning severity (survivor symptoms ranged from headache to loss of consciousness). In a number of cases, several family members succumbed to CO poisoning associated with exposure to generator fumes; deaths were due to acute, high level, CO poisoning. Victims' blood carboxyhemoglobin (COHb) levels *(which can provide information on minimum CO exposure levels, as further explained in the next section)* were documented for 86 of the 138 generator-related deaths that were investigated. In the majority of cases where COHb levels were known (82/86 fatalities), victims had CO levels of at least 40%. Blood levels of 60% COHb or more were found in 62/86 victims, indicating that CO exposure levels most likely exceeded 1000 parts per million (ppm).

In the majority of fatal cases, the victims were found dead at the scene, although they were not necessarily in the room or enclosed space in which the generator had been operating. Health Sciences'(HS) review of the investigated incidents found in several cases, that generators were either found still running, or in a "switched on state" apparently having exhausted the fuel supply. There is a significant lack of data regarding the size of generators involved in the fatal incidents that have been subject to IDI; generator size was unknown for 56/138 of the investigated fatalities. In the 82 cases where size was known, all but one engine was rated below 7 kilowatts, and the most prevalent classes of generator engines were rated between 5.0-5.9 kilowatts (33 cases), and between 3.0-3.9 kilowatts (19 cases) (see Carlson, 2004).

**Carbon Monoxide Poisoning Pathophysiology**

Carbon monoxide is a colorless, odorless, poisonous gas formed during incomplete combustion of fossil fuels. Initial CO poisoning effects result primarily from oxygen ($O_2$) deprivation (hypoxia) due to compromised uptake, transport, and delivery to cells. Compared to $O_2$, CO has approximately a 250-fold higher affinity for hemoglobin. Thus, inhaled CO rapidly enters the bloodstream and effectively displaces $O_2$ from red blood cells, resulting in formation of carboxyhemoglobin (COHb). CO can also displace $O_2$ from the muscle protein myoglobin, but this usually does not occur until after COHb levels have been significantly elevated. The heart, brain, and exercising muscle are the tissues with the highest oxygen requirements;

consequently, they are most sensitive to CO-induced hypoxia. This 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. When CO levels rise steeply and suddenly, as is believed to be the case with generators, it is possible for exposed individuals to rapidly experience confusion, loss of muscular coordination, and loss of consciousness. This can occur without having first experienced milder CO poisoning symptoms associated with a low, or slowly rising, CO level.

Although the relationship is not absolute, the blood level of COHb (% COHb, i.e., percent of the total hemoglobin pool occupied by CO) serves as a useful approximation of CO poisoning severity, with increasing % COHb levels typically associated with progressively worsening symptoms (Table 1).

**Table 1. Approximate Correlation Between % COHb Level and Symptoms in Healthy Adults**

| % COHb | Symptoms |
|---|---|
| <10% | No perceptible ill effects* |
| 10-20 | Mild headache, labored breathing, decreased exercise tolerance |
| 20-30 | Throbbing headache, mild nausea |
| 30-40 | Severe headache, dizziness, nausea, vomiting, cognitive impairment |
| 40-50 | Confusion, unconsciousness, coma, possible death |
| 50-70 | Coma, brain damage, seizures, death |
| >70 | Typically fatal |

(Source: Burton, 1996) * Some studies have reported adverse health effects in some cardiac patients at 2-5% COHb

The three primary factors that influence COHb formation (and elimination) from exogenous CO exposures are: (i) the concentration of CO in inspired air (ppm CO), (ii) the duration of exposure, and (iii) an individual's physical activity level. The highest COHb level that can be reached for any CO exposure is limited by the ppm level of CO in air. If CO is maintained at any given ppm level, COHb levels will progress to an equilibrium state where COHb formation and elimination are equal and the % COHb is limited by the CO concentration in air. Under sedentary conditions, more than 80% of the equilibrium value is reached within an 8 hour exposure, and equilibrium will usually be reached within 10 to 12 hours. The activity level of exposed individuals plays a key role in the rate at which COHb levels rise prior to attainment of equilibrium COHb levels. Individuals engaged in strenuous activities breathe rapidly; therefore, their CO intake is greater and COHb formation faster than in resting individuals. At higher activity levels and depending on the ppm level, more than 90% of the equilibrium COHb level can be reached within 4 hours. For most household activities, breathing rates or respiratory minute volumes (RMV) of residents typically range from about 6 liters per minute (L/min) at sleep or rest, to about 20 L/min for moderate activity. Higher RMVs (30 L/min or more) can be reached by individuals engaged in more strenuous activities and RMVs of about 40 to 50 L/min can be maintained for relatively short periods by those engaged in extremely heavy exercise. The relationships between CO ppm, duration of exposure, activity levels, and COHb formation are illustrated in Table 2.

**Table 2. Relationships between CO level (ppm), Duration of Exposure, and Exposed Individuals' Activity Level on Carboxyhemoglobin (% COHb) Levels**

| Activity Level (RMVs) | CO (ppm) | % COHb* at Different Duration Exposures and at Equilibrium | | | |
|---|---|---|---|---|---|
| | | 1 hour | 4 hours | 8 hours | Equilibrium |
| | | | | | |
| **Resting/sleep** | **100** | 2.6 | 6.0 | 9.1 | 14.5 |
| **(6 L/min)** | **200** | 4.0 | 11.0 | 17.0 | 25.3 |
| | **300** | 5.5 | 15.8 | 24.3 | 33.7 |
| | **400** | 7.0 | 20.6 | 30.9 | 40.3 |
| | **500** | 8.4 | 25.2 | 36.9 | 45.7 |
| | **750** | 12.1 | 35.9 | 49.3 | 55.8 |
| | **1000** | 15.7 | 45.5 | 58.3 | 62.7 |
| | | | | | |
| **Low** | **100** | 3.6 | 8.6 | 11.9 | 14.4 |
| **(10 L/min)** | **200** | 6.2 | 16.2 | 21.9 | 25.2 |
| | **300** | 8.8 | 23.2 | 30.3 | 33.6 |
| | **400** | 11.3 | 29.7 | 37.4 | 40.2 |
| | **500** | 13.9 | 35.6 | 43.4 | 45.7 |
| | **750** | 20.1 | 48.0 | 54.5 | 55.8 |
| | **1000** | 26.3 | 57.3 | 62.0 | 62.7 |
| | | | | | |
| **Moderate** | **100** | 5.8 | 12.1 | 13.9 | 14.3 |
| **(20 L/min)** | **200** | 10.8 | 22.3 | 24.8 | 25.2 |
| | **300** | 15.6 | 30.7 | 33.2 | 33.5 |
| | **400** | 20.2 | 37.8 | 40.0 | 40.2 |
| | **500** | 24.8 | 43.7 | 45.5 | 45.7 |
| | **750** | 35.5 | 54.7 | 55.7 | 55.7 |
| | **1000** | 45.0 | 62.2 | 62.7 | 62.7 |
| | | | | | |
| **High** | **100** | 7.61 | 13.4 | 14.2 | 14.3 |
| **(30 L/min)** | **200** | 14.3 | 24.2 | 25.1 | 25.2 |
| | **300** | 20.6 | 32.7 | 33.5 | 33.5 |
| | **400** | 26.6 | 39.6 | 40.2 | 40.2 |
| | **500** | 32.2 | 45.2 | 45.6 | 45.6 |
| | **750** | 44.5 | 55.6 | 55.7 | 55.7 |
| | **1000** | 54.2 | 62.6 | 62.7 | 62.7 |

* % COHb estimated by CPSC Health Sciences staff using a customized computer model for the non-linear form of the *Coburn Forster Kane* equation with modifications of *Peterson and Stewart.* The following input parameters were used: 70 kg male; blood volume = 5,500 ml; baseline % COHb = 1.2% (urban non-smoker); Haldane constant = 218; barometric pressure = 760 torr (sea level)

While it is convenient to use discrete COHb levels to categorize symptom severity, clearly, the severity of symptoms associated with CO poisoning cannot be explained simply in terms of the maximum % COHb reached (or a maximum CO ppm level of exposure). Symptom severity is also influenced by the length of time that the individual's % COHb has been elevated, and by an individual's susceptibility to CO. Thus, symptom severity is a function of the level and duration of tissue hypoxia and is primarily determined by the rate at which the CO level increases, the maximum CO level reached (ppm), the duration of exposure, the exposed individual's activity level, and their general health status. The CO poisoning symptoms listed in Table 1 should therefore be regarded as part of a continuum of effects with overlapping transitions. Below 10% COHb, no perceptible effects of CO exposure are likely in healthy adults. Mild headaches and fatigue become evident between 10 to 20% COHb. At 20 to 30% COHb, throbbing headaches and nausea are likely initially, and severe headache, nausea, vomiting, cognitive impairment, and possible loss of consciousness can result if levels are sustained for a long time, or rise above 30% COHb. Such symptoms can seriously compromise the ability of exposed individuals to remove themselves from the hazardous environment. In healthy individuals, attaining a COHb level above 60% presents a significant risk of a fatal outcome and levels exceeding 70% COHb typically result in death. Fatalities can, and do, occur in healthy individuals at COHb elevations around 40-50%, generally in situations where the elevation has been sustained for several hours. Fatalities can also occur at much lower COHb levels in certain populations who are particularly susceptible to oxygen deprivation due to pre-exisiting conditions that compromise oxygen uptake and/or delivery to tissues (e.g., compromised heart or lung function, certain anemias), or due to particularly high metabolic demands for oxygen (e.g., fetuses, young children).

For some individuals who survive serious prolonged COHb elevations (usually above 20% COHb), the resulting brain hypoxia, and any consequent associated brain damage, may ultimately result in the phenomenon of delayed neurological sequelae (DNS). DNS is typically manifested within a few days or weeks after the apparent recovery from the initial CO exposure. Symptoms can include emotional instability, memory loss, dementia, psychosis, Parkinsonism, incontinence, blindness, paralysis, and peripheral neuropathy. Symptoms of DNS may respond to hyperbaric oxygen therapy and/or may resolve spontaneously over a two-year period, but victims exhibiting the most severe symptoms such as Parkinsonism, blindness, and paralysis are often permanently affected (US EPA, 2000). While loss of consciousness is typically associated with more serious outcomes, it is not necessary to have lost consciousness to sustain DNS from CO exposures.

**Recent CPSC Laboratory Activities**

The increasing number of generator-related CO poisoning fatalities reported to CPSC provides strong evidence regarding the lethal CO hazard presented by a generator when it is operated within an enclosed or poorly ventilated environment. In order to gain a greater understanding of factors that influence how rapidly a CO exposure from generator emissions can progress to a likely fatal outcome, CPSC staff has undertaken some experimental studies. The most recent of these activities are focused on a laboratory test program to measure CO emission rates of representative generators. In order to derive CO source strengths for sample test generators under different load conditions, CPSC staff in the Directorate for Laboratory Sciences (LS), is conducting a series of ongoing tests of generators inside a controlled, 339 $ft^3$

environmental test chamber (see J. Buyer, 2004). In late March 2004, preliminary CO source strengths, derived by LS staff for a sample 5.5 kilowatt generator operating under different load conditions, were used to model time-course profiles for CO (ppm) buildup and decay in different regions of a hypothetical model home (see Table 3).

| Table 3. Preliminary Source Strengths Derived for a 5.5 Kilowatt, Gasoline-Powered Generator* | |
|---|---|
| **Load** | **CO emissions in cc/hr** |
| No Load | 676,604 |
| Partial Load | 1,017,576 |
| Full Load | 1,182,518 |

(*preliminary data provided to S. Inkster, (HS) by W. Porter, (LS), March 25, 2004)

For these modeling studies, LS staff assumed that the generator was operating in the enclosed basement (750 $ft^2$, [6,000 $ft^3$]) of a representative 4-bedroom, single-family home (total area and volume including basement = 2,250 $ft^2$ and 18,000 $ft^3$, respectively). For each of the source strengths listed in Table 3, a general assumption was made that the generator had run continuously for 6 hours before running out of fuel. The EPA's computer-based RISK 1.9.22 Indoor Air Modeling program was used to model the buildup and decay of CO ppm in different areas of the home, over an 18 hour period. Modeling of the source strength data was performed for two different scenarios considered appropriate to the generator hazard pattern. In the first scenario, the heating and ventilating air conditioning (HVAC) system was considered inoperative. For the second scenario, the generator was considered to supply sufficient power to run the air circulation fan of a typical HVAC system, but not enough power to run the compressor of an air conditioning system, or a heat pump. The HVAC air circulation fan was assumed to operate at an airflow rate of 2,500 $ft^3$/minute. The values for air exchange rates (AER) used in modeling by LS staff, fell within the range of values for these parameters that is documented in the literature (see EPA Exposure Factors Handbook, 1997). The following values were used by LS staff:

| | |
|---|---|
| AER within the house: | (a) 0.75 air changes per hour [ACH] between floors |
| | (b) 3.0 ACH between adjacent rooms, |
| AER with the outdoors: | (c) 0.3 ACH for the basement |
| | (d) 0.5 ACH for the "above ground" house levels |
| | *(personal communication to S. Inkster from W. Porter, 03/25/04).* |

For convenience, HS staff has incorporated LS staff's preliminary modeled data for CO time course profiles throughout the home model, into the summary tables A1 to A6 in the Appendix section of this memorandum.

**Health Sciences Modeling of Carboxyhemoglobin Levels**

In order to characterize and assess the CO poisoning risk associated with a consumer product, HS staff typically estimates the % COHb profile and/or peak % COHb level expected in exposed individuals. This is based on the source product's CO emissions, and/or the peak environmental CO level attained and the expected use scenarios for the specific product and user populations. A differential equation developed by Coburn-Forster and Kane (CFK equation) considers the major physical and physiological factors that affect COHb levels (1965). The non-linear form of the CFK, which corrects the available hemoglobin pool for the amount in the form of COHb, is widely regarded in the medical research community as the most physiologically accurate, predictive model for estimating COHb levels that has the broadest application for different CO exposure scenarios (U.S. EPA, 2000). HS staff developed a customized computer-based program for the non-linear form of the CFK equation, and routinely uses this for COHb modeling studies (Babich, 1993). The program has been validated against previously published human test data for CO exposures up to 1000 ppm. For safety and ethical reasons, controlled experimental data on prolonged human exposure to high levels of CO (> 1000 ppm) is not available. As such, HS staff cannot verify the validity of the computer CFK model for estimating COHb levels at such high level CO exposures associated with generator emissions. However, HS staff has no reason to believe that it is grossly inaccurate at higher levels. HS staff cautions that it should be clearly recognized that use of any model to predict COHb levels will give **approximate** estimates, the reliability of which will be dependent on how closely the input values represent the population characteristics and environmental exposure conditions.

To characterize the health hazard posed by operating a 5.5 kilowatt generator in a basement, HS staff used LS staff's derived CO profiles to model the corresponding % COHb profiles for hypothetical adult victims in different regions of the representative single family home. For each CO profile, HS staff modeled the COHb profiles using breathing rates representative of the range of most typical household activities i.e., RMVs of 6 L/min for sleeping/resting individuals, and 20 L/min for moderate activity.

**Results**

Staff notes that these preliminary modeled data are meant to apply to an average situation. Obviously, the size of a home and the rates of air exchange with the outdoor environment significantly impact the development of the potential CO hazard within the home. Larger homes and higher air exchange rates would reduce the hazard and smaller homes and lower air exchange rates would exacerbate the hazard.

The summary tables (Appendix A) present HS staff's data for the predicted % COHb profiles, together with LS staff's corresponding modeled CO ppm profiles. The modeled COHb profiles are also presented graphically in Appendix B of this memorandum. To facilitate comparison of the numerous COHb profiles generated, HS staff collated the data for the size and time of the approximate peak CO level predicted and the approximate peak % COHb levels reached and time attained for the resting and moderate activity exposure scenarios. These summary data are shown in Table 4. HS staff also derived from the modeled data, the approximate times at which the hypothetical victim would attain a COHb level of 20%, 40% and, if applicable, 60% (Table 5). The 20% COHb level is used by HS staff to represent the critical level at which the possibility exists that DNS could be manifested in surviving victims, and as a minimal level at which lucid decision making could be impaired by prolonged exposures. Attainment of 40% COHb is considered to reflect likely incapacitation due to severe cognitive impairment of victims and likely loss of consciousness; death is possible with prolonged elevations of 40% COHb. The 60% COHb level is considered to represent a level at which a fatal outcome is likely.

LS and HS staffs' modeling studies of LS staff's CO emissions data from generator tests show that a 5.5 kilowatt generator is capable of generating lethal CO exposures throughout a representative single family home. LS staff's data shows that in 33 of 36 cases, the maximum CO level estimated for all areas of a home exceeded 1200 ppm, a level defined by NIOSH as being Immediately Dangerous to Life and Health[2]. The corresponding peak COHb levels predicted by HS staff exceeded 60% in 69/72 cases and exceeded 70% in 54/72 modeled scenarios. The three predicted CO levels that did not reach 1200 ppm were all predicted for areas in the upper level of a home in which a generator was operating in the basement with no load, and in which the HVAC fan was inoperative. HS staff notes that the general 6 hour run time applied by LS staff is likely to underestimate the peak CO levels reached and duration of CO exposure. This is because the "lack of load" scenario would be expected to reduce the rate of consumption of fuel significantly, and consequently, would result in longer duration of operation and extended duration of CO production. The lack of load scenario is not considered to be representative of how most consumers would use a generator in their homes (personal communication from T. Smith, CPSC Human Factors staff, and J. Buyer, CPSC Engineering Staff).

The modeling data shows the influence of an HVAC fan in evenly distributing the CO emissions from the basement area to the rest of the home. While significantly higher levels were always found in the basement area for any modeled scenario, operation of the HVAC fan reduced the range of peak CO levels throughout the rest of the home; for each modeled scenario the range of peak CO levels in all areas except the basement, did not exceed 60 ppm. This resulted in virtually identical peak % COHb levels estimated within identical time frames for each scenario (see Table 4). In contrast, when the HVAC fan was not operating, a gradient of peak CO ppm levels and corresponding % COHb levels was evident from the basement to the upper level of the home. Peak CO levels ranging between 5,740 and 10,032 ppm, corresponding to COHb levels exceeding 85%, were predicted for the basement; minimum levels between 967 and 1,690 ppm, corresponding to peak COHb levels between 53% and 74%, were predicted for bedrooms 1 and 2, depending on an exposed individual's activity level.

The data demonstrate how the operation of the HVAC, the location of an exposed individual, and the exposed individual's relative activity level can influence the rate at which the CO exposure progresses to likely incapacitation (40% COHb) and likely lethal outcome (60% COHb). The status of the HVAC system modulates the developing CO hazard. By evenly distributing the CO throughout the home, an operating HVAC fan can increase the rate at which the hazard develops for victims in upper levels of the home and reduce the hazard in the lower levels, compared to situations in which the fan is off. Obviously, individuals with higher activity levels will accumulate CO more rapidly, and so will reach the 40% COHb level, at which incapacitation is assumed, much faster than resting individuals in identical locations. CPSC staff considers a generator operating at full load as a likely consumer use scenario. An individual in the basement is likely to be incapacitated within 40 and 29 minutes, and dead by 62 and 40 minutes (HVAC on/HVAC off, respectively) of operation of a generator at full load. For victims

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[2] The Immediately Dangerous to Life or Health concentration (IDLH) is defined by NIOSH as *the concentration that could result in death or irreversible health effects, or prevent escape from the contaminated environment within 30 minutes";* the NIOSH IDLH recommended for CO is 1200 ppm (NIOSH ALERT, 1996)

in upper levels (e.g., bedrooms 1 and 2), 40% COHb will be reached after 146 minutes and 232 minutes, and lethal levels reached by 201 and 300 minutes (HVAC on/HVAC off, respectively). The rapid development of the lethal situation explains why HS staff's review of investigated incidents found that, in many cases, victims of generator-related CO poisoning were found dead within a few hours after family or friends had noticed that they were missing.

**Conclusions**

Authoritative sources have documented that use of small engines can cause CO levels to rise rapidly in the immediate vicinity in which they are used, reaching levels that can result in loss of consciousness, and ultimately death (see NIOSH Alert 1996, Publication No. 96-118). Frequently, the CO level rises so quickly that exposed individuals do not recognize they are in danger before their ability to think clearly and remove themselves from the hazardous environment is seriously compromised. One study reported in the NIOSH Alert tested a 5.5-horsepower, gasoline-powered pressure washer operated inside an 8,360-cubic-foot, double-car garage. The washer was found to be capable of elevating CO levels in the user's breathing zone to 200 ppm within 5 minutes, 1,200 ppm (IDLH value) within 15 minutes, and 1,500 ppm within 19 minutes, when all doors windows and vents were closed. When these ventilation routes were left open, CO measurements taken in the breathing zone were 200 ppm within 3 minutes, with a peak of 658 ppm within 12 minutes. Similar findings were reported with other engines, rated from 5 to 8 horsepower. The CPSC staff's data indicates how the CO hazard is expected to develop in other areas of a representative home and demonstrates that lethal outcome is the most likely if a 5.5 kilowatt generator is operated in a basement and no outside intervention occurs. The modeling studies found that, depending on generator load and HVAC fan status, moderately active individuals could be expected to attain lethal COHb levels (60% COHb) between 40 and 68 minutes if in the basement, and between 201 and 326 minutes if in the upper level bedrooms.

The CO hazard associated with use of any combustion product is related to the efficiency of combustion. For most combustion products routinely used by consumers (e.g., furnaces, ranges, space heaters), the efficiency of combustion is highly dependent on the available oxygen supply, and safety devices are in place to shut down modern appliances if efficiency is significantly impaired. Unlike these products, generators and other small engine-driven tools have much lower combustion efficiencies and so produce large amounts of CO during normal operation without serious depletion of the available oxygen. These small engine-driven tools will generally continue running until the fuel supply is exhausted, and they typically lack emissions controls or have any safety design features that shut off the products in the event of excess CO production.

Operation of gasoline-powered generators in enclosed spaces, such as a basement, can rapidly cause ambient CO to reach life-threatening levels in all areas of a home. This can seriously compromise an exposed individual's ability to escape from the hazardous environment, particularly if they are in the same room as the generator, whereby incapacitation can occur within 30 minutes. When used inside the confines of a basement, garage or crawlspace, the CO hazard created by generators is not obvious to all consumers and deaths are likely to continue occurring without intervention strategies.

**References**

Burton LE, (July 1, 1996) CPSC Health Sciences Memorandum, Toxicity from Low Level Human Exposure to Carbon Monoxide.

Buyer J, (February, 2004) CPSC Engineering Sciences Memorandum, Test Program for Engine-Driven Tools Project: Phase 1 Test Plan.

Carlson S, (March 8, 2004) CPSC Epidemiology Hazard Analysis Memorandum, Incidents, Deaths, and In-Depth Investigations Associated with Carbon Monoxide and Engine Driven Tools, 1990-2003.

Coburn RF, Forster RE, Kane PB, (1965) Considerations of the physiological variables that determine the blood carboxyhemoglobin concentration in man. J. Clinical Investigation, 44:1899-1910.

Code of Federal Regulations (July 1, 2003), 40 CFR Part 90, Control of emissions from nonroad spark-ignition engines at or below 19 kilowatts.

Donaldson MF, (April 12, 2004) CPSC Economics Memorandum, Portable Generators.

NIOSH ALERT (1996), DHHS (NIOSH) Publication No. 96-118, Preventing Carbon Monoxide Poisoning from Small Gasoline-Powered Engines and Tools, joint publication by NIOSH CDPHE, CPSC, OSHA, EPA.

Porter W, (March 25, 2004) CPSC Chemistry Laboratory- personal communication with S. Inkster, CPSC Health Sciences, regarding modeled CO Concentrations from engine-powered generators.

U.S. EPA, (1997) Exposure Factors Handbook, Vol. III, Activity Factors, Ch. 17, Residential Building Characteristics, EPA/600/P-95-002Fa, August 1997.

U.S. EPA, (2000) Air quality Criteria for Carbon Monoxide, EPA 600/P-99/001F. (website http://www.epa.gov/NCEA/pdfs/coaqcd.pdf)

Vagts S, (June 19, 2002) CPSC Epidemiology Hazard Analysis Memorandum, Carbon Monoxide Incidents Associated with Engine-Driven Tools.

**Table 4. MODELING OF CO EMISSIONS FROM A 5.5 KILOWATT GASOLINE-POWERED GENERATOR UNDER DIFFERENT LOAD CONDITIONS: ESTIMATED PEAK CO AND %COHb LEVELS, AND CORRESPONDING TIMES WHEN REACHED**

**ESTIMATES OF THE APPROXIMATE PEAK CO LEVEL (ppm) AND TIME REACHED (hours:minutes)**

| *Generator Load* | *NONE* | | | | *PARTIAL* | | | | *FULL* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *HVAC Fan Status* | *OFF* | | *ON* | | *OFF* | | *ON* | | *OFF* | | *ON* | |
| Room | peak CO (ppm) | time reached | peak CO (ppm) | time reached | peak CO (ppm) | time reached | peak CO (ppm) | time reached | peak CO (ppm) | time reached | peak CO (ppm) | time reached |
| Basement | 5740 | 5:45 | 2232 | 5:45 | 8632 | 5:45 | 3273 | 5:45 | 10032 | 5:45 | 3803 | 5:45 |
| Kitchen (Eat In) | 2704 | 5:45 | 1246 | 6:15 | 4066 | 5:45 | 1860 | 6:15 | 4724 | 5:45 | 2162 | 6:15 |
| Living and Dining Rooms | 2297 | 6:15 | 1223 | 6:15 | 3455 | 6:15 | 1842 | 6:15 | 4015 | 6:15 | 2140 | 6:15 |
| Bedroom 1 and 2 | 967 | 7:15 | 1228 | 6:15 | 1455 | 7:15 | 1824 | 6:15 | 1690 | 7:15 | 2120 | 6:15 |
| Bedroom 3 and 4 | 979 | 7:15 | 1210 | 6:15 | 1473 | 7:15 | 1821 | 6:15 | 1711 | 7:15 | 2116 | 6:15 |
| Hall (Upstairs) | 1136 | 6:45 | 1227 | 6:15 | 1709 | 6:45 | 1830 | 6:15 | 1986 | 6:45 | 2127 | 6:15 |

**ESTIMATES OF THE APPROXIMATE PEAK % COHb AND TIME REACHED (hours:minutes) FOR A RESTING INDIVIDUAL (RMV 6 L/min)**

| *Generator Load* | *NONE* | | | | *PARTIAL* | | | | *FULL* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *HVAC Fan Status* | *OFF* | | *ON* | | *OFF* | | *ON* | | *OFF* | | *ON* | |
| Room | Peak %COHb | time reached | Peak %COHb | time reached | Peak %COHb | time reached | Peak %COHb | time reached | Peak %COHb | time reached | Peak %COHb | time reached |
| Basement | 84* | 2:45* | 76 | 7:45 | 88* | 2:15* | 83* | 5:15 | 82* | 1:45* | 87* | 4:15 |
| Kitchen (Eat In) | 81 | 6:45 | 62 | 9:45 | 87* | 5:45* | 73 | 8:45 | 79* | 3:45* | 77 | 7:45 |
| Living and Dining Rooms | 77 | 7:15 | 62 | 9:45 | 83* | 5:45* | 73 | 8:45 | 84* | 5:15* | 76 | 7:45 |
| Bedroom 1 and 2 | 53 | 10:45 | 62 | 9:45 | 66 | 9:45 | 73 | 8:45 | 71 | 9:15 | 76 | 7:45 |
| Bedroom 3 and 4 | 53 | 10:15 | 62 | 9:45 | 66 | 9:45 | 73 | 8:45 | 71 | 9:15 | 76 | 7:45 |
| Hall (Upstairs) | 58 | 9:45 | 62 | 9:45 | 71 | 8:45 | 73 | 8:45 | 75 | 8:45 | 76 | 7:45 |

**ESTIMATES OF THE APPROXIMATE PEAK % COHb AND TIME REACHED (hours:minutes) FOR A MODERATELY ACTIVE INDIVIDUAL (RMV 20 L/min)**

| *Generator Load* | *NONE* | | | | *PARTIAL* | | | | *FULL* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *HVAC Fan Status* | *OFF* | | *ON* | | *OFF* | | *ON* | | *OFF* | | *ON* | |
| Room | Peak %COHb | time reached | Peak %COHb | time reached | Peak %COHb | time reached | Peak %COHb | time reached | Peak %COHb | time reached | Peak %COHb | time reached |
| Basement | 85* | 1:45* | 79 | 5:45 | 62* | 0:45* | 84 | 5:15* | 86* | 1:15* | 85* | 4:15 |
| Kitchen (Eat In) | 82 | 6:15 | 67 | 6:45 | 87* | 5:75* | 75 | 6:45 | 85* | 3:34* | 78 | 6:45 |
| Living and Dining Rooms | 79 | 6:45 | 67 | 6:45 | 78* | 3:15 | 75 | 6:45 | 85* | 5:15* | 78 | 6:45 |
| Bedroom 1 and 2 | 61 | 8:15 | 67 | 6:45 | 71 | 7:45 | 75 | 6:45 | 74 | 7:45 | 78 | 6:45 |
| Bedroom 3 and 4 | 62 | 7:45 | 67 | 6:45 | 71 | 7:45 | 75 | 6:45 | 74 | 7:45 | 78 | 6:45 |
| Hall (Upstairs) | 65 | 7:15 | 67 | 6:45 | 74 | 7:15 | 75 | 6:45 | 77 | 7:15 | 78 | 6:45 |

* Indicates that the projected % COHb exceeded 100% within 30 minutes of the time shown for the peak % COHb level

Table 5. MODELING OF CO EMISSIONS FROM A 5.5 KILOWATT GASOLINE-POWERED GENERATOR UNDER DIFFERENT LOAD CONDITIONS
ESTIMATED TIMES (hours:minutes) INDIVIDUALS IN DIFFERENT HOME LOCATIONS ATTAIN 20%, 40% and 60% COHb : effect of activity level

| NO LOAD | Time to 20% COHb (hours:mins) | | | | Time to 40% COHb (hours:mins) | | | | Time to 60% COHb (hours:mins) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6L/min | | 20L/min | | 6L/min | | 20L/min | | 6L/min | | 20L/min | |
| | HVAC on | HVAC off | HVAC on | HVAC off | HVAC on | HVAC off | HVAC on | HVAC off | HVAC on | HVAC off | HVAC on | HVAC off |
| Basement | 1:23 | 0:55 | 0:34 | 0:24 | 2:27 | 1:25 | 1:02 | 0:41 | 3:42 | 1:54 | 1:38 | 1:00 |
| Kitchen | 3:37 | 2:10 | 2:05 | 1:16 | 5:28 | 3:09 | 3:12 | 1:48 | 8:07 | 4:08 | 4:58 | 2:27 |
| Living/Dining room | 3:45 | 2:58 | 2:10 | 1:51 | 5:36 | 4:00 | 3:18 | 2:29 | 8:14 | 5:06 | 5:04 | 3:13 |
| Bedroom 1+2 | 3:44 | 5:16 | 2:08 | 3:33 | 5:33 | 7:27 | 3:16 | 4:52 | 8:15 | Max 53% | 5:01 | 7:10 |
| Bedroom 3+4 | 3:47 | 5:06 | 2:12 | 3:24 | 5:38 | 7:15 | 3:21 | 4:42 | 8:20 | Max 53% | 5:07 | 7:00 |
| Upstairs Hall | 3:58 | 4:25 | 2:24 | 2:48 | 5:50 | 6:17 | 3:38 | 4:00 | 8:21 | Max 58% | 5:16 | 5:45 |

| PARTIAL LOAD | Time to 20% COHb (hours:mins) | | | | Time to 40% COHb (hours:mins) | | | | Time to 60% COHb (hours:mins) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6L/min | | 20L/min | | 6L/min | | 20L/min | | 6L/min | | 20L/min | |
| | HVAC on | HVAC off | HVAC on | HVAC off | HVAC on | HVAC off | HVAC on | HVAC off | HVAC on | HVAC off | HVAC on | HVAC off |
| Basement | 1:02 | 0:44 | 0:26 | 0:21 | 1:48 | 1:06 | 0:45 | 0:37 | 2:40 | 1:29 | 1:08 | 0:45 |
| Kitchen | 2:58 | 1:48 | 1:43 | 1:03 | 4:22 | 2:33 | 2:34 | 1:29 | 5:45 | 3:15 | 3:37 | 1:56 |
| Living/Dining room | 3:05 | 2:27 | 1:47 | 1:36 | 4:28 | 3:18 | 2:38 | 2:07 | 5:53 | 4:07 | 3:43 | 2:38 |
| Bedroom 1+2 | 3:04 | 4:31 | 1:46 | 3:07 | 4:27 | 6:07 | 2:37 | 4:06 | 5:52 | 7:52 | 3:42 | 5:26 |
| Bedroom 3+4 | 3:06 | 4:22 | 1:49 | 2:58 | 4:31 | 5:55 | 2:39 | 3:45** | 5:54 | 7:38 | 3:44 | 4:28 |
| Upstairs Hall | 3:18 | 3:43 | 2:02 | 2:23 | 4:44 | 5:08 | 2.53 | 3:18 | 6:07 | 6:35 | 4:00 | 4:25 |

| FULL LOAD | Time to 20% COHb (hours:mins) | | | | Time to 40% COHb (hours:mins) | | | | Time to 60% COHb (hours:mins) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6L/min | | 20L/min | | 6L/min | | 20L/min | | 6L/min | | 20L/min | |
| | HVAC on | HVAC off | HVAC on | HVAC off | HVAC on | HVAC off | HVAC on | HVAC off | HVAC on | HVAC off | HVAC on | HVAC off |
| Basement | 0:55 | 0:38 | 0:24 | 0:18 | 1:36 | 1:02 | 0:40 | 0:29 | 2:20 | 1:21 | 1:02 | 0:40 |
| Kitchen | 2:45 | 1:42 | 1:35 | 0:58 | 4:02 | 2:23 | 2:21 | 1:24 | 5:13 | 3:02 | 3:15 | 1:47 |
| Living/Dining room | 2:51 | 2:18 | 1:40 | 1:31 | 4:08 | 3:07 | 2:27 | 2:00 | 5:23 | 3:49 | 3:22 | 2:30 |
| Bedroom 1+2 | 2:50 | 4:17 | 1:38 | 2:56 | 4:07 | 5:43 | 2:26 | 3:52 | 5:21 | 7:11 | 3:21 | 5:00 |
| Bedroom 3+4 | 2:53 | 4:07 | 1:42 | 2:48 | 4:09 | 5:32 | 2:29 | 3:43 | 5:24 | 6:58 | 3:24 | 4:47 |
| Upstairs Hall | 3:05 | 3:30 | 1:54 | 2:16 | 4:23 | 4:48 | 2:41 | 3:05 | 5:37 | 6:04 | 3:38 | 4:04 |

# APPENDIX A

## SUMMARY TABLES (A1-A6) OF TIME COURSE DATA FOR MODELED CO (ppm) AND % COHb PROFILES

## Appendix A1. LS and HS Modeling Results for Generic Generator 5.5 kW, No Load, No HVAC

| Time | ppm CO | % COHb | % COHb | ppm CO | % COHb | % COHb | ppm CO | % COHb | % COHb | ppm CO | % COHb | % COHb | ppm CO | % COHb | % COHb | ppm CO | % COHb | % COHb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| hours | Basement | 20L/mn | 6L/min | Kitchen | 20L/mn | 6L/min | LR & DR | 20L/mn | 6L/min | BR 1 & 2 | 20L/mn | 6L/min | BR 3 & 4 | 20L/mn | 6L/min | upstairs | 20L/mn | 6L/min |
| 0 | | 1.2 | 1.2 | | 1.2 | 1.2 | | 1.2 | 1.2 | | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 |
| 0.25 | 886.1 | 7.4 | 2.8 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 |
| 0.75 | 2139.8 | 44.5 | 14.0 | 354.8 | 5.8 | 2.4 | 65.1 | 1.8 | 1.4 | 0.0 | 0.9 | 1.1 | 0.0 | 0.9 | 1.1 | 27.4 | 1.3 | 1.2 |
| 1.25 | 3003.9 | 75.9 | 32.3 | 718.9 | 19.2 | 6.4 | 294.9 | 6.5 | 2.7 | 26.0 | 1.1 | 1.2 | 35.2 | 1.3 | 1.2 | 94.9 | 2.8 | 1.6 |
| 1.75 | 3632.9 | 84.2 | 53.6 | 1063.1 | 37.8 | 12.8 | 577.6 | 17.1 | 5.8 | 78.9 | 2.4 | 1.5 | 98.0 | 2.9 | 1.7 | 187.1 | 6.2 | 2.6 |
| 2.25 | 4112.5 | | 72.8 | 1374.4 | 55.5 | 21.2 | 863.0 | 32.2 | 11.0 | 152.6 | 5.2 | 2.3 | 179.8 | 6.2 | 2.7 | 294.1 | 11.6 | 4.3 |
| 2.75 | 4491.7 | | 83.8 | 1650.1 | 67.2 | 31.1 | 1129.2 | 48.2 | 17.9 | 240.4 | 9.7 | 3.7 | 273.3 | 11.3 | 4.3 | 408.4 | 18.9 | 6.8 |
| 3.25 | 4799.8 | | | 1891.5 | 73.3 | 41.9 | 1368.8 | 60.8 | 26.1 | 336.1 | 15.7 | 5.7 | 372.2 | 17.9 | 6.5 | 524.6 | 27.2 | 10.0 |
| 3.75 | 5055.0 | | | 2102.0 | 76.4 | 52.7 | 1580.4 | 68.4 | 35.3 | 434.8 | 22.8 | 8.4 | 472.3 | 25.4 | 9.4 | 638.8 | 35.9 | 13.8 |
| 4.25 | 5269.3 | | | 2285.1 | 78.3 | 62.5 | 1765.7 | 72.6 | 44.9 | 532.8 | 30.5 | 11.6 | 570.4 | 33.2 | 12.8 | 748.5 | 44.0 | 18.3 |
| 4.75 | 5451.0 | | | 2444.3 | 79.7 | 70.4 | 1927.3 | 75.1 | 54.2 | 627.7 | 38.1 | 15.4 | 664.3 | 40.6 | 16.8 | 852.0 | 50.8 | 23.2 |
| 5.25 | 5606.3 | | | 2582.9 | 80.7 | 75.9 | 2067.9 | 76.7 | 62.4 | 717.7 | 44.8 | 19.6 | 752.8 | 47.1 | 21.1 | 948.4 | 56.1 | 28.5 |
| 5.75 | 5739.8 | | | 2703.7 | 81.5 | 79.2 | 2190.4 | 77.9 | 69.1 | 802.0 | 50.4 | 24.1 | 835.1 | 52.3 | 25.8 | 1037.2 | 59.9 | 34.0 |
| 6.25 | 4280.0 | | | 2633.1 | 81.7 | 80.7 | 2297.1 | 78.9 | 73.8 | 880.0 | 54.8 | 28.9 | 910.8 | 56.3 | 30.7 | 1118.5 | 62.8 | 39.5 |
| 6.75 | 3345.9 | | | 2363.0 | 80.9 | 80.8 | 2221.9 | 79.1 | 76.6 | 941.5 | 58.1 | 33.8 | 965.6 | 59.2 | 35.6 | 1136.3 | 64.5 | 44.7 |
| 7.25 | 2700.0 | | | 2087.0 | 79.2 | 79.7 | 2037.8 | 78.3 | 77.4 | 967.1 | 60.2 | 38.4 | 979.1 | 60.9 | 40.2 | 1120.7 | 65.1 | 49.2 |
| 7.75 | 2228.9 | | | 1829.0 | 77.1 | 78.2 | 1820.8 | 76.7 | 76.9 | 962.1 | 61.2 | 42.6 | 962.7 | 61.6 | 44.2 | 1079.9 | 65.0 | 52.7 |
| 8.25 | 1869.8 | | | 1597.3 | 74.8 | 76.4 | 1605.6 | 74.7 | 75.7 | 933.6 | 61.3 | 46.2 | 925.3 | 61.4 | 47.5 | 1022.4 | 64.2 | 55.3 |
| 8.75 | 1586.3 | | | 1393.2 | 72.3 | 74.4 | 1406.8 | 72.4 | 74.1 | 889.0 | 60.8 | 48.9 | 874.3 | 60.7 | 50.0 | 954.8 | 63.1 | 57.0 |
| 9.25 | 1356.7 | | | 1215.3 | 69.7 | 72.3 | 1229.0 | 69.8 | 72.2 | 834.1 | 59.8 | 50.9 | 815.4 | 59.5 | 51.7 | 882.2 | 61.6 | 57.8 |
| 9.75 | 1167.2 | | | 1060.8 | 66.9 | 70.2 | 1072.8 | 67.2 | 70.1 | 773.7 | 58.5 | 52.2 | 752.5 | 58.0 | 52.7 | 808.4 | 59.9 | 58.0 |
| 10.25 | 1008.5 | | | 926.8 | 64.1 | 68.0 | 936.6 | 64.4 | 68.0 | 711.1 | 56.9 | 52.8 | 688.9 | 56.3 | 53.1 | 735.8 | 58.0 | 57.7 |
| 10.75 | 874.4 | | | 810.5 | 61.3 | 65.7 | 818.2 | 61.5 | 65.8 | 648.8 | 55.1 | 52.9 | 626.6 | 54.4 | 53.0 | 666.1 | 55.9 | 57.0 |
| 11.25 | 760.2 | | | 709.5 | 58.4 | 63.5 | 715.4 | 58.6 | 63.6 | 588.6 | 53.1 | 52.6 | 566.9 | 52.3 | 52.5 | 600.3 | 53.8 | 56.0 |
| 11.75 | 662.4 | | | 621.7 | 55.5 | 61.2 | 626.1 | 55.7 | 61.3 | 531.4 | 50.9 | 51.9 | 510.8 | 50.1 | 51.7 | 539.2 | 51.5 | 54.8 |
| 12.25 | 578.2 | | | 545.3 | 52.6 | 59.0 | 548.5 | 52.8 | 59.1 | 477.9 | 48.7 | 51.0 | 458.5 | 47.9 | 50.7 | 482.8 | 49.1 | 53.4 |
| 12.75 | 505.5 | | | 478.6 | 49.8 | 56.8 | 480.9 | 49.9 | 56.9 | 428.4 | 46.4 | 49.9 | 410.4 | 45.6 | 49.5 | 431.2 | 46.8 | 51.9 |
| 13.25 | 442.5 | | | 420.3 | 47.0 | 54.7 | 422.0 | 47.1 | 54.8 | 383.0 | 44.1 | 48.6 | 366.5 | 43.3 | 48.2 | 384.4 | 44.4 | 50.4 |
| 13.75 | 387.7 | | | 369.4 | 44.2 | 52.5 | 370.5 | 44.3 | 52.6 | 341.7 | 41.8 | 47.3 | 326.7 | 40.9 | 46.8 | 342.1 | 42.0 | 48.7 |
| 14.25 | 340.1 | | | 324.8 | 41.5 | 50.5 | 325.6 | 41.6 | 50.5 | 304.3 | 39.5 | 45.8 | 290.7 | 38.6 | 45.3 | 304.0 | 39.6 | 47.1 |
| 14.75 | 298.5 | | | 285.6 | 38.9 | 48.4 | 286.2 | 39.0 | 48.5 | 270.6 | 37.2 | 44.4 | 258.3 | 36.3 | 43.8 | 269.9 | 37.3 | 45.4 |
| 15.25 | 262.2 | | | 251.3 | 36.4 | 46.5 | 251.7 | 36.5 | 46.5 | 240.3 | 35.0 | 42.8 | 229.2 | 34.1 | 42.3 | 239.3 | 35.0 | 43.8 |
| 15.75 | 230.4 | | | 221.2 | 34.0 | 44.5 | 221.4 | 34.0 | 44.6 | 213.1 | 32.8 | 41.3 | 203.2 | 31.9 | 40.7 | 212.0 | 32.8 | 42.1 |
| 16.25 | 202.6 | | | 194.8 | 31.6 | 42.7 | 194.9 | 31.7 | 42.7 | 188.9 | 30.6 | 39.8 | 180.0 | 29.8 | 39.2 | 187.7 | 30.6 | 40.5 |
| 16.75 | 178.3 | | | 171.5 | 29.4 | 40.8 | 171.6 | 29.4 | 40.9 | 167.3 | 28.6 | 38.3 | 159.4 | 27.8 | 37.7 | 166.1 | 28.5 | 38.9 |
| 17.25 | 156.9 | | | 151.1 | 27.3 | 39.1 | 151.1 | 27.3 | 39.1 | 148.1 | 26.6 | 36.8 | 141.0 | 25.8 | 36.2 | 146.9 | 26.5 | 37.3 |
| 17.75 | 138.1 | | | 133.1 | 25.3 | 37.4 | 133.1 | 25.3 | 37.4 | 131.0 | 24.7 | 35.3 | 124.7 | 24.0 | 34.8 | 129.8 | 24.6 | 35.8 |
| 18.25 | 121.6 | | | 117.3 | 23.4 | 35.8 | 117.2 | 23.4 | 35.8 | 115.8 | 22.9 | 33.9 | 110.2 | 22.2 | 33.3 | 114.7 | 22.8 | 34.3 |
| 18.75 | 121.6 | | | 117.3 | 21.7 | 34.2 | 117.2 | 21.7 | 34.3 | 115.8 | 21.4 | 32.5 | 110.2 | 20.7 | 32.0 | 114.7 | 21.3 | 32.9 |

## Appendix A2 LS and HS Modeling Results for Generic Generator 5.5 kW, No Load, with HVAC

| Time | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| hours | Basement | 20L/min | 6L/min | Kitchen | 20L/min | 6L/min | LR&DR | 20L/min | 6L/min | BR 1&2 | 20L/min | 6L/min | BR 3&4 | 20L/min | 6L/min | upstairs | 20L/min | 6L/min |
| 0 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 |
| 0.25 | 664.1 | 5.9 | 2.4 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 |
| 0.75 | 1121.1 | 28.4 | 9.0 | 117.8 | 2.5 | 1.6 | 98.4 | 2.3 | 1.5 | 105.7 | 2.4 | 1.5 | 97.0 | 2.2 | 1.5 | 53.5 | 1.6 | 1.3 |
| 1.25 | 1296.0 | 50.4 | 17.6 | 244.4 | 7.1 | 2.9 | 221.0 | 6.3 | 2.6 | 228.1 | 6.6 | 2.7 | 216.5 | 6.2 | 2.6 | 165.5 | 4.4 | 2.1 |
| 1.75 | 1422.2 | 63.3 | 26.7 | 367.4 | 14.1 | 5.0 | 342.1 | 12.8 | 4.6 | 350.0 | 13.2 | 4.8 | 337.0 | 12.6 | 4.6 | 285.7 | 9.8 | 3.7 |
| 2.25 | 1537.1 | 69.2 | 35.9 | 486.3 | 22.7 | 8.0 | 459.4 | 21.1 | 7.4 | 468.4 | 21.6 | 7.6 | 454.1 | 20.8 | 7.3 | 404.4 | 17.3 | 6.1 |
| 2.75 | 1647.0 | 72.0 | 44.8 | 601.1 | 31.9 | 11.7 | 572.8 | 30.1 | 11.0 | 582.8 | 30.7 | 11.2 | 567.4 | 29.7 | 10.8 | 519.7 | 26.0 | 9.3 |
| 3.25 | 1753.0 | 73.6 | 53.1 | 712.0 | 40.7 | 16.0 | 682.4 | 38.8 | 15.1 | 693.3 | 39.5 | 15.4 | 676.9 | 38.5 | 14.9 | 631.3 | 34.9 | 13.2 |
| 3.75 | 1855.4 | 74.9 | 60.4 | 819.3 | 48.3 | 20.9 | 788.3 | 46.6 | 19.8 | 800.2 | 47.2 | 20.2 | 782.8 | 46.3 | 19.6 | 739.1 | 43.2 | 17.6 |
| 4.25 | 1954.4 | 76.0 | 66.4 | 922.9 | 54.3 | 26.1 | 890.6 | 52.9 | 24.9 | 903.5 | 53.4 | 25.3 | 885.0 | 52.6 | 24.7 | 843.4 | 50.2 | 22.5 |
| 4.75 | 2050.1 | 76.9 | 71.0 | 1023.1 | 58.9 | 31.7 | 989.6 | 57.7 | 30.3 | 1003.3 | 58.2 | 30.8 | 983.9 | 57.5 | 30.1 | 944.2 | 55.7 | 27.8 |
| 5.25 | 2142.6 | 77.7 | 74.2 | 1120.0 | 62.3 | 37.4 | 1085.2 | 61.3 | 36.0 | 1099.7 | 61.7 | 36.5 | 1079.4 | 61.1 | 35.7 | 1041.6 | 59.8 | 33.4 |
| 5.75 | 2232.0 | 78.5 | 76.4 | 1213.6 | 64.9 | 43.2 | 1177.6 | 64.1 | 41.7 | 1193.0 | 64.4 | 42.2 | 1171.8 | 63.9 | 41.4 | 1135.7 | 62.9 | 39.1 |
| 6.25 | 1353.3 | 75.7 | 75.8 | 1245.8 | 66.6 | 48.6 | 1223.4 | 66.0 | 47.1 | 1228.0 | 66.2 | 47.6 | 1210.1 | 65.8 | 46.8 | 1226.7 | 65.3 | 44.7 |
| 6.75 | 1180.9 | 70.2 | 73.0 | 1209.7 | 67.1 | 53.1 | 1192.8 | 66.7 | 51.7 | 1201.1 | 66.8 | 52.2 | 1188.3 | 66.5 | 51.4 | 1211.9 | 66.6 | 49.8 |
| 7.75 | 1080.1 | 66.2 | 69.2 | 1130.2 | 66.4 | 58.7 | 1115.9 | 66.1 | 57.7 | 1125.7 | 66.2 | 58.1 | 1114.8 | 66.0 | 57.4 | 1137.1 | 66.4 | 56.6 |
| 8.75 | 1008.4 | 64.1 | 66.7 | 1055.9 | 65.0 | 61.3 | 1042.5 | 64.7 | 60.6 | 1051.9 | 64.9 | 60.9 | 1041.7 | 64.7 | 60.4 | 1062.2 | 65.1 | 60.2 |
| 9.75 | 942.0 | 62.5 | 64.7 | 986.4 | 63.5 | 62.1 | 973.9 | 63.2 | 61.5 | 982.7 | 63.4 | 61.8 | 973.2 | 63.2 | 61.5 | 992.3 | 63.6 | 61.5 |
| 10.75 | 880.0 | 60.9 | 62.9 | 921.5 | 61.9 | 61.9 | 909.9 | 61.7 | 61.5 | 918.0 | 61.9 | 61.7 | 909.2 | 61.6 | 61.4 | 927.0 | 62.1 | 61.6 |
| 11.75 | 822.1 | 59.3 | 61.3 | 860.9 | 60.4 | 61.1 | 850.0 | 60.1 | 60.8 | 857.6 | 60.3 | 61.0 | 849.4 | 60.1 | 60.7 | 866.0 | 60.5 | 61.0 |
| 12.75 | 768.0 | 58.1 | 60.4 | 804.2 | 59.2 | 60.5 | 794.1 | 58.9 | 60.1 | 801.2 | 59.1 | 60.4 | 793.5 | 58.9 | 60.1 | 809.0 | 59.3 | 60.4 |
| 13.75 | 717.5 | 55.9 | 58.2 | 751.3 | 57.0 | 58.7 | 741.8 | 56.7 | 58.4 | 748.5 | 56.9 | 58.6 | 741.3 | 56.7 | 58.3 | 755.8 | 57.2 | 58.7 |
| 14.75 | 670.3 | 54.4 | 56.7 | 701.9 | 55.5 | 57.4 | 693.0 | 55.2 | 57.1 | 699.2 | 55.4 | 57.3 | 692.5 | 55.2 | 57.1 | 706.1 | 55.7 | 57.5 |
| 15.75 | 626.2 | 52.8 | 55.3 | 655.7 | 53.9 | 56.1 | 647.4 | 53.6 | 55.8 | 653.2 | 53.8 | 56.0 | 646.9 | 53.6 | 55.7 | 659.6 | 54.0 | 56.1 |
| 16.75 | 585.0 | 51.2 | 53.8 | 612.6 | 52.3 | 54.7 | 604.8 | 52.0 | 54.4 | 610.2 | 52.2 | 54.6 | 604.4 | 52.0 | 54.4 | 616.2 | 52.4 | 54.8 |
| 17.75 | 546.5 | 49.5 | 52.3 | 572.3 | 50.6 | 53.2 | 565.0 | 50.3 | 53.0 | 570.1 | 50.6 | 53.1 | 564.6 | 50.3 | 52.9 | 575.7 | 50.8 | 53.3 |
| 18.25 | 528.2 | 48.2 | 51.0 | 553.1 | 49.3 | 51.9 | 546.1 | 49.0 | 51.6 | 551.0 | 49.2 | 51.8 | 545.7 | 48.9 | 51.6 | 556.4 | 49.4 | 52.0 |

## Appendix A3. LS and HS Modeling Results for Generic Generator 5.5 kW, Partial Load, No HVAC

| Time hours | ppm CO Basement | % COHb 20L/min | % COHb 6L/min | ppm CO Kitchen | %COHb 20L/min | % COHb 6L/min | ppm CO LR & DR | % COHb 20L/min | % COHb 6L/min | ppm CO BR 1 & 2 | % COHb 20L/min | % COHb 6L/min | ppm CO BR 3 & 4 | % COHb 20L/min | % COHb 6L/min | ppm CO Hall | % COHb 20L/min | % COHb 6L/min |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | ***0*** | 1.2 | 1.2 | ***0*** | 1.2 | 1.2 | ***0*** | 1.2 | 1.2 | ***0*** | 1.2 | 1.2 | ***0*** | 1.2 | 1.2 | ***0*** | 1.2 | 1.2 |
| 0.25 | ***1332.7*** | 10.6 | 3.7 | ***0.0*** | 1.1 | 1.1 | ***0.0*** | 1.1 | 1.1 | ***0.0*** | 1.1 | 1.1 | ***0.0*** | 1.1 | 1.1 | ***0.0*** | 1.1 | 1.1 |
| 0.75 | ***3218.1*** | 61.6 | 20.5 | ***533.5*** | 8.2 | 3.1 | ***98.0*** | 2.3 | 1.5 | ***0.0*** | 0.9 | 1.1 | ***0.0*** | 0.9 | 1.1 | ***41.3*** | 1.5 | 1.3 |
| 1.25 | ***4517.7*** | | 47.4 | ***1081.2*** | 28.0 | 9.0 | ***443.5*** | 9.3 | 3.5 | ***39.2*** | 1.3 | 1.2 | ***53.0*** | 1.5 | 1.3 | ***142.7*** | 3.8 | 1.9 |
| 1.75 | ***5463.7*** | | 74.7 | ***1598.8*** | 52.8 | 18.6 | ***868.7*** | 25.0 | 8.2 | ***118.6*** | 3.3 | 1.8 | ***147.4*** | 4.0 | 2.0 | ***281.4*** | 8.9 | 3.4 |
| 2.25 | ***6185.0*** | | 88.1 | ***2067.1*** | 70.3 | 31.1 | ***1297.8*** | 45.8 | 15.9 | ***229.6*** | 7.5 | 3.0 | ***270.5*** | 9.0 | 3.5 | ***442.3*** | 17.0 | 6.0 |
| 2.75 | ***6755.3*** | | | ***2481.6*** | 78.0 | 45.4 | ***1698.3*** | 63.7 | 26.2 | ***361.6*** | 14.2 | 5.1 | ***411.0*** | 16.6 | 5.9 | ***614.2*** | 27.5 | 9.7 |
| 3.25 | ***7218.6*** | | | ***2844.8*** | 81.4 | 59.9 | ***2058.6*** | 73.5 | 38.3 | ***505.5*** | 22.9 | 8.1 | ***559.8*** | 26.0 | 9.3 | ***789.0*** | 38.8 | 14.5 |
| 3.75 | ***7602.4*** | | | ***3161.3*** | 83.3 | 72.2 | ***2376.9*** | 78.1 | 51.2 | ***653.9*** | 32.9 | 12.1 | ***710.3*** | 36.4 | 13.6 | ***960.8*** | 49.5 | 20.2 |
| 4.25 | ***7924.7*** | | | ***3436.6*** | 84.6 | 80.1 | ***2655.6*** | | 63.4 | ***801.3*** | 42.9 | 16.9 | ***857.8*** | 46.2 | 18.7 | ***1125.7*** | 57.9 | 26.8 |
| 4.75 | ***8198.0*** | | | ***3676.1*** | 85.6 | 84.0 | ***2898.5*** | | 73.1 | ***944.0*** | 51.6 | 22.5 | ***999.1*** | 54.3 | 24.6 | ***1281.4*** | 63.9 | 34.0 |
| 5.25 | ***8431.6*** | | | ***3884.6*** | 86.4 | 85.8 | ***3110.1*** | | 79.3 | ***1079.4*** | 58.3 | 28.7 | ***1132.2*** | 60.4 | 30.9 | ***1426.3*** | 67.8 | 41.5 |
| 5.75 | ***8632.3*** | | | ***4066.2*** | 87.0 | 86.7 | ***3294.3*** | | 82.6 | ***1206.1*** | 63.1 | 35.2 | ***1255.9*** | 64.6 | 37.6 | ***1559.9*** | 70.6 | 48.9 |
| 6.25 | ***6436.9*** | | | ***3960.1*** | | | ***3454.8*** | | | ***1323.4*** | 66.5 | 41.9 | ***1369.8*** | 67.6 | 44.4 | ***1682.1*** | 72.6 | 56.0 |
| 6.75 | ***5032.1*** | | | ***3553.8*** | | | ***3341.6*** | | | ***1416.0*** | 68.8 | 48.5 | ***1452.2*** | 69.6 | 50.8 | ***1709.0*** | 73.7 | 61.9 |
| 7.25 | ***4060.6*** | | | ***3138.7*** | | | ***3064.7*** | | | ***1454.5*** | 70.2 | 54.4 | ***1472.5*** | 70.7 | 56.5 | ***1685.4*** | 74.0 | 66.3 |
| 7.75 | ***3352.1*** | | | ***2750.7*** | | | ***2738.4*** | | | ***1446.9*** | 70.7 | 59.2 | ***1447.8*** | 70.9 | 60.8 | ***1624.1*** | 73.6 | 69.0 |
| 8.25 | ***2812.1*** | | | ***2402.2*** | | | ***2414.8*** | | | ***1404.1*** | 70.6 | 62.7 | ***1391.6*** | 70.6 | 63.9 | ***1537.6*** | 72.9 | 70.4 |
| 8.75 | ***2385.8*** | | | ***2095.3*** | | | ***2115.7*** | | | ***1337.0*** | 70.0 | 64.9 | ***1315.0*** | 69.8 | 65.7 | ***1435.9*** | 71.8 | 70.8 |
| 9.25 | ***2040.4*** | | | ***1827.7*** | | | ***1848.4*** | | | ***1254.5*** | 68.9 | 66.1 | ***1226.2*** | 68.6 | 66.4 | ***1326.8*** | 70.4 | 70.5 |
| 9.75 | ***1755.4*** | | | ***1595.4*** | | | ***1613.4*** | | | ***1163.6*** | 67.6 | 66.4 | ***1131.8*** | 67.1 | 66.4 | ***1215.8*** | 68.8 | 69.7 |
| 10.25 | ***1516.8*** | | | ***1393.8*** | | | ***1408.6*** | | | ***1069.5*** | 66.0 | 66.0 | ***1036.1*** | 65.4 | 65.9 | ***1106.6*** | 67.0 | 68.6 |
| 10.75 | ***1315.1*** | | | ***1219.0*** | | | ***1230.5*** | | | ***975.8*** | 64.2 | 65.3 | ***942.4*** | 63.5 | 65.0 | ***1001.7*** | 65.0 | 67.2 |
| 11.25 | ***1143.4*** | | | ***1067.1*** | | | ***1075.9*** | | | ***885.2*** | 62.2 | 64.2 | ***852.6*** | 61.5 | 63.8 | ***902.9*** | 62.8 | 65.7 |
| 11.75 | ***996.2*** | | | ***935.1*** | | | ***941.7*** | | | ***799.2*** | 60.1 | 62.8 | ***768.1*** | 59.3 | 62.3 | ***810.9*** | 60.6 | 64.0 |
| 12.25 | ***869.6*** | | | ***820.1*** | | | ***824.9*** | | | ***718.7*** | 57.9 | 61.3 | ***689.6*** | 57.0 | 60.8 | ***726.1*** | 58.2 | 62.3 |
| 12.75 | ***760.2*** | | | ***719.8*** | | | ***723.3*** | | | ***644.3*** | 55.5 | 59.7 | ***617.3*** | 54.6 | 59.1 | ***648.6*** | 55.8 | 60.5 |
| 13.25 | ***665.4*** | | | ***632.1*** | | | ***634.7*** | | | ***576.0*** | 53.1 | 58.0 | ***551.3*** | 52.2 | 57.4 | ***578.2*** | 53.3 | 58.6 |
| 13.75 | ***583.1*** | | | ***555.5*** | | | ***557.3*** | | | ***513.9*** | 50.7 | 56.2 | ***491.3*** | 49.7 | 55.6 | ***514.5*** | 50.8 | 56.7 |
| 14.25 | ***511.4*** | | | ***488.4*** | | | ***489.6*** | | | ***457.6*** | 48.2 | 54.4 | ***437.1*** | 47.3 | 53.7 | ***457.2*** | 48.3 | 54.8 |
| 14.75 | ***448.9*** | | | ***429.6*** | | | ***430.4*** | | | ***406.9*** | 45.7 | 52.6 | ***388.4*** | 44.8 | 51.9 | ***405.8*** | 45.8 | 52.9 |
| 15.25 | ***394.3*** | | | ***378.0*** | | | ***378.5*** | | | ***361.4*** | 43.3 | 50.7 | ***344.7*** | 42.3 | 50.0 | ***359.9*** | 43.2 | 51.0 |
| 15.75 | ***346.6*** | | | ***332.7*** | | | ***333.0*** | | | ***320.5*** | 40.8 | 48.9 | ***305.6*** | 39.9 | 48.2 | ***318.8*** | 40.8 | 49.1 |
| 16.25 | ***304.8*** | | | ***293.0*** | | | ***293.1*** | | | ***284.1*** | 38.4 | 47.1 | ***270.8*** | 37.5 | 46.4 | ***282.3*** | 38.3 | 47.3 |
| 16.75 | ***268.1*** | | | ***258.0*** | | | ***258.0*** | | | ***251.6*** | 36.0 | 45.3 | ***239.7*** | 35.1 | 44.6 | ***249.8*** | 36.0 | 45.4 |
| 17.25 | ***235.9*** | | | ***227.2*** | | | ***227.2*** | | | ***222.7*** | 33.7 | 43.5 | ***212.1*** | 32.9 | 42.9 | ***220.9*** | 33.6 | 43.6 |
| 17.75 | ***207.7*** | | | ***200.2*** | | | ***200.1*** | | | ***197.0*** | 31.5 | 41.8 | ***187.5*** | 30.7 | 41.1 | ***195.3*** | 31.4 | 41.9 |
| 18.25 | ***182.9*** | | | ***176.4*** | | | ***176.3*** | | | ***174.1*** | 29.4 | 40.1 | ***165.8*** | 28.6 | 39.5 | ***172.5*** | 29.3 | 40.2 |
| 18.75 | ***182.9*** | | | ***176.4*** | | | ***176.3*** | | | ***174.1*** | 27.6 | 38.5 | ***165.8*** | 26.8 | 37.9 | ***172.5*** | 27.5 | 38.6 |

## Appendix A4. LS and HS Modeling Results for Generic Generator 5.5 kW, Partial Load, with HVAC

| Time | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| hours | Basement | 20L/min | 6L/min | Kitchen | 20L/min | 6L/min | LR&DR | 20L/min | 6L/min | BR 1&2 | 20L/min | 6L/min | BR 3&4 | 20L/min | 6L/min | upstairs | 20L/min | 6L/min |
| 0 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.16 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 |
| 0.25 | 990.5771 | 8.2 | 3.0 | 0 | 1.1 | 1.1 | 0 | 1.1 | 1.1 | 0 | 1.1 | 1.14 | 0 | 1.1 | 1.1 | 0 | 1.1 | 1.1 |
| 0.75 | 1657.4 | 40.6 | 12.8 | 179.5 | 3.4 | 1.8 | 148.6 | 2.9 | 1.7 | 157.4 | 3.1 | 1.70 | 146.2 | 2.9 | 1.7 | 79.8 | 2.0 | 1.4 |
| 1.25 | 1910.0 | 65.9 | 25.4 | 369.4 | 10.3 | 3.8 | 333.7 | 9.1 | 3.4 | 339.5 | 9.3 | 3.51 | 326.3 | 8.9 | 3.4 | 247.0 | 6.2 | 2.6 |
| 1.75 | 2093.3 | 75.1 | 38.5 | 553.2 | 20.7 | 7.1 | 516.4 | 18.8 | 6.5 | 520.8 | 19.2 | 6.59 | 507.7 | 18.5 | 6.4 | 426.5 | 14.2 | 5.0 |
| 2.25 | 2260.6 | 78.0 | 51.0 | 730.5 | 32.9 | 11.6 | 693.1 | 30.6 | 10.7 | 696.7 | 31.0 | 10.85 | 684.1 | 30.2 | 10.5 | 603.7 | 25.0 | 8.7 |
| 2.75 | 2420.8 | 79.5 | 62.2 | 901.7 | 44.8 | 17.1 | 863.7 | 42.6 | 16.0 | 866.7 | 42.9 | 16.15 | 854.7 | 42.1 | 15.8 | 775.8 | 37.0 | 13.4 |
| 3.25 | 2575.2 | 80.6 | 70.9 | 1067.1 | 54.7 | 23.5 | 1028.6 | 52.9 | 22.2 | 1030.9 | 53.1 | 22.34 | 1019.5 | 52.4 | 21.9 | 942.2 | 48.1 | 19.1 |
| 3.75 | 2724.4 | 81.6 | 76.8 | 1226.9 | 61.8 | 30.5 | 1187.9 | 60.5 | 29.1 | 1189.6 | 60.6 | 29.23 | 1178.7 | 60.1 | 28.7 | 1103.1 | 56.9 | 25.6 |
| 4.25 | 2868.6 | 82.4 | 80.2 | 1381.4 | 66.6 | 38.0 | 1341.8 | 65.6 | 36.5 | 1342.9 | 65.7 | 36.62 | 1332.5 | 65.4 | 36.1 | 1258.7 | 63.2 | 32.8 |
| 4.75 | 3007.8 | 83.1 | 82.1 | 1530.6 | 69.8 | 45.7 | 1490.5 | 69.1 | 44.1 | 1491.0 | 69.1 | 44.22 | 1481.1 | 68.9 | 43.7 | 1408.9 | 67.4 | 40.2 |
| 5.25 | 3142.4 | 83.7 | 83.2 | 1674.8 | 72.2 | 53.2 | 1634.2 | 71.6 | 51.6 | 1634.1 | 71.6 | 51.71 | 1624.7 | 71.5 | 51.2 | 1554.1 | 70.3 | 47.8 |
| 5.75 | 3272.5 | | | 1814.1 | 74.1 | 60.2 | 1773.1 | 73.6 | 58.6 | 1772.4 | 73.6 | 58.71 | 1763.5 | 73.5 | 58.3 | 1694.5 | 72.5 | 55.1 |
| 6.25 | 1966.6 | | | 1860.1 | 75.3 | 65.9 | 1841.8 | 74.9 | 64.6 | 1824.0 | 74.8 | 64.59 | 1820.9 | 74.8 | 64.2 | 1830.0 | 74.3 | 61.7 |
| 6.75 | 1718.0 | | | 1803.4 | 75.4 | 69.7 | 1794.4 | 75.3 | 68.8 | 1783.1 | 75.1 | 68.72 | 1787.2 | 75.1 | 68.5 | 1807.9 | 75.1 | 66.8 |
| 7.75 | 1572.0 | | | 1683.3 | 74.6 | 72.7 | 1677.4 | 74.5 | 72.2 | 1670.3 | 74.4 | 72.14 | 1675.8 | 74.5 | 72.1 | 1695.4 | 74.7 | 71.5 |
| 8.75 | 1467.0 | | | 1571.6 | 73.3 | 73.0 | 1566.3 | 73.3 | 72.8 | 1560.0 | 73.2 | 72.71 | 1565.2 | 73.2 | 72.7 | 1582.9 | 73.5 | 72.6 |
| 9.75 | 1369.7 | | | 1467.4 | 72.0 | 72.4 | 1462.5 | 71.9 | 72.2 | 1456.6 | 71.8 | 72.14 | 1461.4 | 71.9 | 72.2 | 1477.8 | 72.1 | 72.3 |
| 10.75 | 1278.9 | | | 1370.1 | 70.6 | 71.3 | 1365.5 | 70.5 | 71.2 | 1360.0 | 70.5 | 71.12 | 1364.5 | 70.5 | 71.2 | 1379.8 | 70.8 | 71.3 |
| 11.75 | 1194.1 | | | 1279.2 | 69.2 | 70.1 | 1274.9 | 69.1 | 70.0 | 1269.8 | 69.0 | 69.92 | 1274.0 | 69.1 | 70.0 | 1288.3 | 69.3 | 70.2 |
| 12.75 | 1114.9 | | | 1194.4 | 68.0 | 69.2 | 1190.4 | 67.9 | 69.2 | 1185.6 | 67.9 | 69.08 | 1189.6 | 67.9 | 69.1 | 1202.9 | 68.2 | 69.3 |
| 13.75 | 1040.9 | | | 1115.2 | 66.1 | 67.3 | 1111.5 | 66.1 | 67.2 | 1107.0 | 66.0 | 67.13 | 1110.7 | 66.1 | 67.2 | 1123.1 | 66.3 | 67.4 |
| 14.75 | 971.9 | | | 1041.2 | 64.7 | 66.0 | 1037.7 | 64.6 | 65.9 | 1033.6 | 64.5 | 65.82 | 1037.0 | 64.6 | 65.9 | 1048.6 | 64.9 | 66.1 |
| 15.75 | 907.5 | | | 972.2 | 63.2 | 64.6 | 968.9 | 63.1 | 64.5 | 965.0 | 63.0 | 64.44 | 968.3 | 63.1 | 64.5 | 979.1 | 63.3 | 64.7 |
| 16.75 | 847.3 | | | 907.7 | 61.6 | 63.2 | 904.7 | 61.5 | 63.1 | 901.0 | 61.4 | 63.04 | 904.0 | 61.5 | 63.1 | 914.2 | 61.8 | 63.3 |
| 17.75 | 791.1 | | | 847.5 | 60.0 | 61.8 | 844.7 | 59.9 | 61.7 | 841.3 | 59.8 | 61.60 | 844.1 | 59.9 | 61.7 | 853.6 | 60.2 | 61.9 |
| 18.25 | 764.4 | | | 819.0 | 58.7 | 60.5 | 816.2 | 58.6 | 60.4 | 812.9 | 58.5 | 60.30 | 815.6 | 58.6 | 60.4 | 824.8 | 58.9 | 60.6 |

## *Appendix A5. LS and HS Modeling Results for Generic Generator 5.5 kW, Full Load, No HVAC*

| Time | ppm CO | % COHb | % COHb | ppm CO | % COHb | % COHb | ppm CO | % COHb | % COHb | ppm CO | % COHb | % COHb | ppm CO | % COHb | % COHb | ppm CO | % COHb | % COHb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| hours | Basement | 20L/min | 6L/min | Kitchen | 20L/min | 6L/min | LR & DR | 20L/min | 6L/min | BR1 & 2 | 20L/min | 6L/min | BR 3 & 4 | 20L/min | 6L/min | upstairs | 20L/min | 6L/min |
| 0 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 |
| 0.25 | 1548.7 | 12.2 | 4.1 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 |
| 0.75 | 3739.8 | 68.1 | 23.6 | 620.0 | 9.4 | 3.4 | 113.8 | 2.5 | 1.5 | 0.0 | 0.9 | 1.1 | 0.0 | 0.9 | 1.1 | 47.9 | 1.6 | 1.3 |
| 1.25 | 5250.0 | | 54.3 | 1256.5 | 32.1 | 10.3 | 515.4 | 10.7 | 3.8 | 45.5 | 1.4 | 1.2 | 61.6 | 1.6 | 1.3 | 165.8 | 4.3 | 2.0 |
| 1.75 | 6349.3 | | 81.8 | 1857.9 | 58.9 | 21.4 | 1009.6 | 28.7 | 9.4 | 137.8 | 3.7 | 1.9 | 171.3 | 4.6 | 2.1 | 327.0 | 10.2 | 3.8 |
| 2.25 | 7187.5 | | | 2402.1 | 74.8 | 35.8 | 1508.2 | 51.6 | 18.3 | 266.8 | 8.6 | 3.3 | 314.3 | 10.4 | 3.9 | 514.0 | 19.6 | 6.8 |
| 2.75 | 7850.3 | | | 2883.9 | 80.9 | 52.0 | 1973.6 | 68.9 | 30.2 | 420.2 | 16.3 | 5.8 | 477.6 | 19.1 | 6.7 | 713.8 | 31.4 | 11.1 |
| 3.25 | 8388.7 | | | 3305.9 | 83.7 | 67.4 | 2392.3 | 77.1 | 44.0 | 587.5 | 26.3 | 9.3 | 650.5 | 29.8 | 10.6 | 916.8 | 43.9 | 16.6 |
| 3.75 | 8834.7 | | | 3673.7 | 85.3 | 78.6 | 2762.2 | 80.8 | 58.2 | 759.9 | 37.4 | 13.9 | 825.5 | 41.2 | 15.6 | 1116.5 | 54.8 | 23.3 |
| 4.25 | 9209.2 | | | 3993.7 | | | 3086.0 | 82.9 | 70.7 | 931.2 | 48.1 | 19.5 | 996.9 | 51.5 | 21.5 | 1308.2 | 62.8 | 30.8 |
| 4.75 | 9526.9 | | | 4272.0 | | | 3368.4 | 84.3 | 79.1 | 1097.0 | 56.8 | 25.9 | 1161.1 | 59.4 | 28.3 | 1489.1 | 68.1 | 39.0 |
| 5.25 | 9798.3 | | | 4514.3 | | | 3614.2 | 85.4 | 83.5 | 1254.4 | 63.0 | 33.0 | 1315.7 | 64.9 | 35.6 | 1657.5 | 71.5 | 47.4 |
| 5.75 | 10031.6 | | | 4725.4 | | | 3828.3 | | | 1401.6 | 67.3 | 40.4 | 1459.5 | 68.6 | 43.1 | 1812.8 | 73.8 | 55.5 |
| 6.25 | 7480.3 | | | 4602.0 | | | 4014.8 | | | 1537.9 | 70.2 | 47.8 | 1591.9 | 71.1 | 50.5 | 1954.8 | 75.6 | 62.7 |
| 6.75 | 5847.7 | | | 4129.8 | | | 3883.2 | | | 1645.6 | 72.2 | 54.9 | 1687.5 | 72.9 | 57.4 | 1986.0 | 76.6 | 68.4 |
| 7.25 | 4718.8 | | | 3647.5 | | | 3561.5 | | | 1690.3 | 73.4 | 60.9 | 1711.2 | 73.8 | 63.0 | 1958.6 | 76.8 | 72.1 |
| 7.75 | 3895.5 | | | 3196.6 | | | 3182.3 | | | 1681.4 | 73.8 | 65.5 | 1682.5 | 74.0 | 67.0 | 1887.4 | 76.4 | 74.0 |
| 8.25 | 3267.9 | | | 2791.6 | | | 2806.2 | | | 1631.7 | 73.6 | 68.5 | 1617.2 | 73.6 | 69.5 | 1786.8 | 75.7 | 74.7 |
| 8.75 | 2772.5 | | | 2435.0 | | | 2458.6 | | | 1553.7 | 73.0 | 70.2 | 1528.1 | 72.8 | 70.7 | 1668.7 | 74.6 | 74.6 |
| 9.25 | 2371.2 | | | 2124.0 | | | 2148.0 | | | 1457.8 | 72.0 | 70.7 | 1425.0 | 71.6 | 70.9 | 1541.9 | 73.3 | 73.9 |
| 9.75 | 2039.9 | | | 1853.9 | | | 1875.0 | | | 1352.2 | 70.7 | 70.6 | 1315.2 | 70.2 | 70.5 | 1412.8 | 71.8 | 72.9 |
| 10.25 | 1762.7 | | | 1619.7 | | | 1636.9 | | | 1242.8 | 69.2 | 69.9 | 1204.1 | 68.6 | 69.6 | 1285.9 | 70.0 | 71.6 |
| 10.75 | 1528.3 | | | 1416.5 | | | 1430.0 | | | 1134.0 | 67.4 | 68.8 | 1095.2 | 66.8 | 68.5 | 1164.1 | 68.1 | 70.2 |
| 11.25 | 1328.7 | | | 1240.1 | | | 1250.3 | | | 1028.7 | 65.5 | 67.5 | 990.9 | 64.7 | 67.1 | 1049.2 | 66.1 | 68.6 |
| 11.75 | 1157.7 | | | 1086.6 | | | 1094.3 | | | 928.7 | 63.4 | 66.1 | 892.7 | 62.6 | 65.5 | 942.3 | 63.9 | 66.9 |
| 12.25 | 1010.5 | | | 953.0 | | | 958.6 | | | 835.2 | 61.2 | 64.5 | 801.4 | 60.3 | 63.9 | 843.8 | 61.5 | 65.1 |
| 12.75 | 883.4 | | | 836.4 | | | 840.5 | | | 748.7 | 58.9 | 62.7 | 717.4 | 58.0 | 62.1 | 753.7 | 59.1 | 63.3 |
| 13.25 | 773.3 | | | 734.6 | | | 737.5 | | | 669.4 | 56.5 | 61.0 | 640.6 | 55.6 | 60.3 | 671.9 | 56.7 | 61.4 |
| 13.75 | 677.6 | | | 645.5 | | | 647.6 | | | 597.2 | 54.0 | 59.1 | 570.9 | 53.1 | 58.4 | 597.9 | 54.1 | 59.4 |
| 14.25 | 594.3 | | | 567.6 | | | 569.0 | | | 531.8 | 51.5 | 57.2 | 508.0 | 50.5 | 56.5 | 531.3 | 51.6 | 57.5 |
| 14.75 | 521.7 | | | 499.2 | | | 500.2 | | | 472.9 | 49.0 | 55.3 | 451.4 | 48.0 | 54.6 | 471.6 | 49.0 | 55.5 |
| 15.25 | 458.3 | | | 439.3 | | | 439.9 | | | 419.9 | 46.5 | 53.4 | 400.6 | 45.5 | 52.7 | 418.2 | 46.4 | 53.6 |
| 15.75 | 402.8 | | | 386.7 | | | 387.0 | | | 372.5 | 44.0 | 51.5 | 355.2 | 43.0 | 50.8 | 370.5 | 43.9 | 51.7 |
| 16.25 | 354.2 | | | 340.4 | | | 340.6 | | | 330.1 | 41.5 | 49.7 | 314.6 | 40.5 | 48.9 | 328.0 | 41.4 | 49.7 |
| 16.75 | 311.5 | | | 299.8 | | | 299.9 | | | 292.4 | 39.0 | 47.8 | 278.6 | 38.1 | 47.1 | 290.3 | 38.9 | 47.8 |
| 17.25 | 274.2 | | | 264.1 | | | 264.1 | | | 258.8 | 36.6 | 45.9 | 246.5 | 35.7 | 45.2 | 256.7 | 36.5 | 46.0 |
| 17.75 | 241.3 | | | 232.6 | | | 232.6 | | | 228.9 | 34.3 | 44.1 | 217.9 | 33.4 | 43.4 | 226.9 | 34.2 | 44.2 |
| 18.25 | 212.5 | | | 205.0 | | | 204.9 | | | 202.4 | 32.1 | 42.4 | 192.7 | 31.2 | 41.7 | 200.5 | 31.9 | 42.4 |
| 18.75 | 212.5 | | | 205.0 | | | 204.9 | | | 202.4 | 30.2 | 40.7 | 192.7 | 29.3 | 40.1 | 200.5 | 30.0 | 40.7 |

| Appendix A6. LS and HS Modeling Results for Generic Generator 5.5 kW, Full Load with HVAC | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb | ppm CO | %COHb | %COHb |
| hours | Basement | 20L/min | 6L/min | Kitchen | 20L/min | 6L/min | LR&DR | 20L/min | 6L/min | BR1&2 | 20L/min | 6L/min | BR3&4 | 20L/min | 6L/min | upstairs | 20L/min | 6L/min |
| 0 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 | 0 | 1.2 | 1.2 |
| 0.25 | 1151.1 | 9.3 | 3.3 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 | 0.0 | 1.1 | 1.1 |
| 0.75 | 1926.0 | 46.2 | 14.7 | 208.6 | 3.8 | 1.9 | 172.6 | 3.3 | 1.8 | 182.9 | 3.4 | 1.8 | 169.9 | 3.2 | 1.7 | 92.8 | 2.2 | 1.5 |
| 1.25 | 2219.6 | 71.3 | 29.3 | 429.3 | 11.8 | 4.2 | 387.8 | 10.4 | 3.8 | 394.6 | 10.7 | 3.9 | 379.2 | 10.2 | 3.7 | 287.0 | 7.0 | 2.8 |
| 1.75 | 2432.6 | 78.5 | 44.2 | 642.9 | 23.8 | 8.1 | 600.1 | 21.6 | 7.3 | 605.2 | 22.0 | 7.5 | 590.0 | 21.2 | 7.2 | 495.7 | 16.3 | 5.7 |
| 2.25 | 2627.1 | 80.7 | 58.1 | 848.9 | 37.5 | 13.3 | 805.4 | 35.0 | 12.3 | 809.6 | 35.4 | 12.4 | 795.0 | 34.5 | 12.1 | 701.6 | 28.7 | 9.9 |
| 2.75 | 2813.1 | 81.9 | 69.5 | 1047.9 | 50.2 | 19.6 | 1003.8 | 47.9 | 18.4 | 1007.2 | 48.2 | 18.6 | 993.3 | 47.4 | 18.1 | 901.5 | 41.9 | 15.4 |
| 3.25 | 2992.6 | 82.9 | 77.1 | 1240.1 | 59.9 | 27.0 | 1195.3 | 58.2 | 25.5 | 1198.0 | 58.4 | 25.7 | 1184.7 | 57.8 | 25.2 | 1095.0 | 53.5 | 22.0 |
| 3.75 | 3166.0 | 83.7 | 81.4 | 1425.8 | 66.3 | 35.1 | 1380.5 | 65.1 | 33.4 | 1382.4 | 65.2 | 33.6 | 1369.7 | 64.8 | 33.1 | 1282.0 | 62.0 | 29.5 |
| 4.25 | 3333.5 | 84.5 | 83.5 | 1605.3 | 70.4 | 43.6 | 1559.3 | 69.6 | 41.8 | 1560.6 | 69.6 | 42.0 | 1548.5 | 69.4 | 41.4 | 1462.7 | 67.5 | 37.6 |
| 4.75 | 3495.4 | | | 1778.7 | 73.2 | 52.1 | 1732.1 | 72.6 | 50.2 | 1732.7 | 72.6 | 50.4 | 1721.2 | 72.4 | 49.8 | 1637.3 | 71.1 | 46.0 |
| 5.25 | 3651.8 | | | 1946.2 | 75.3 | 60.0 | 1899.1 | 74.8 | 58.3 | 1899.0 | 74.8 | 58.4 | 1888.1 | 74.7 | 57.9 | 1806.1 | 73.6 | 54.3 |
| 5.75 | 3802.9 | | | 2108.1 | 77.0 | 66.8 | 2060.5 | 76.5 | 65.4 | 2059.7 | 76.5 | 65.4 | 2049.3 | 76.4 | 65.0 | 1969.1 | 75.6 | 61.8 |
| 6.25 | 2285.4 | | | 2161.6 | 78.0 | 71.9 | 2140.4 | 77.7 | 70.8 | 2119.6 | 77.6 | 70.8 | 2116.1 | 77.6 | 70.5 | 2126.7 | 77.2 | 68.2 |
| 6.75 | 1996.5 | | | 2095.7 | 78.1 | 74.9 | 2085.2 | 78.0 | 74.2 | 2072.2 | 77.8 | 74.1 | 2076.9 | 77.8 | 74.0 | 2101.0 | 77.9 | 72.7 |
| 7.75 | 1826.8 | | | 1956.1 | 77.3 | 76.5 | 1949.3 | 77.3 | 76.3 | 1941.1 | 77.2 | 76.2 | 1947.4 | 77.2 | 76.1 | 1970.2 | 77.4 | 75.8 |
| 8.75 | 1704.8 | | | 1826.4 | 76.1 | 76.2 | 1820.2 | 76.1 | 76.1 | 1812.8 | 76.0 | 76.0 | 1818.9 | 76.1 | 76.0 | 1839.4 | 76.3 | 76.1 |
| 9.75 | 1591.7 | | | 1705.2 | 74.9 | 75.3 | 1699.5 | 74.8 | 75.2 | 1692.7 | 74.7 | 75.2 | 1698.3 | 74.8 | 75.2 | 1717.4 | 75.0 | 75.4 |
| 10.75 | 1486.2 | | | 1592.2 | 73.6 | 74.2 | 1586.8 | 73.5 | 74.1 | 1580.4 | 73.4 | 74.0 | 1585.7 | 73.5 | 74.1 | 1603.5 | 73.7 | 74.3 |
| 11.75 | 1387.6 | | | 1486.6 | 72.3 | 73.0 | 1481.6 | 72.2 | 72.9 | 1475.6 | 72.1 | 72.8 | 1480.6 | 72.2 | 72.9 | 1497.2 | 72.4 | 73.1 |
| 12.75 | 1295.6 | | | 1388.0 | 71.1 | 72.1 | 1383.3 | 71.0 | 72.1 | 1377.8 | 71.0 | 72.0 | 1382.4 | 71.0 | 72.0 | 1397.9 | 71.2 | 72.2 |
| 13.75 | 1209.7 | | | 1296.0 | 69.4 | 70.3 | 1291.6 | 69.3 | 70.2 | 1286.4 | 69.2 | 70.1 | 1290.7 | 69.3 | 70.2 | 1305.2 | 69.5 | 70.4 |
| 14.75 | 1129.5 | | | 1210.0 | 68.0 | 69.0 | 1206.0 | 67.9 | 68.9 | 1201.1 | 67.8 | 68.9 | 1205.1 | 67.9 | 68.9 | 1218.6 | 68.2 | 69.1 |
| 15.75 | 1054.6 | | | 1129.8 | 66.5 | 67.7 | 1126.0 | 66.5 | 67.6 | 1121.5 | 66.4 | 67.5 | 1125.2 | 66.4 | 67.6 | 1137.8 | 66.7 | 67.8 |
| 16.75 | 984.6 | | | 1054.9 | 65.0 | 66.3 | 1051.3 | 64.9 | 66.2 | 1047.1 | 64.9 | 66.2 | 1050.6 | 64.9 | 66.2 | 1062.4 | 65.2 | 66.4 |
| 17.75 | 919.3 | | | 984.9 | 63.5 | 64.9 | 981.6 | 63.4 | 64.8 | 977.7 | 63.3 | 64.8 | 980.9 | 63.4 | 64.8 | 991.9 | 63.6 | 65.1 |
| 18.25 | 888.3 | | | 951.7 | 62.2 | 63.6 | 948.5 | 62.1 | 63.6 | 944.7 | 62.1 | 63.5 | 947.8 | 62.1 | 63.6 | 958.5 | 62.4 | 63.8 |

# APPENDIX B

# SUMMARY GRAPHS SHOWING % COHb TIME COURSE PROFILES FOR INDIVIDUALS ENGAGED IN RESTING/LOW OR MODERATE ACTIVITY LEVELS DURING THE FIRST 9 HOURS OF EXPOSURE TO GENERATOR EMISSIONS

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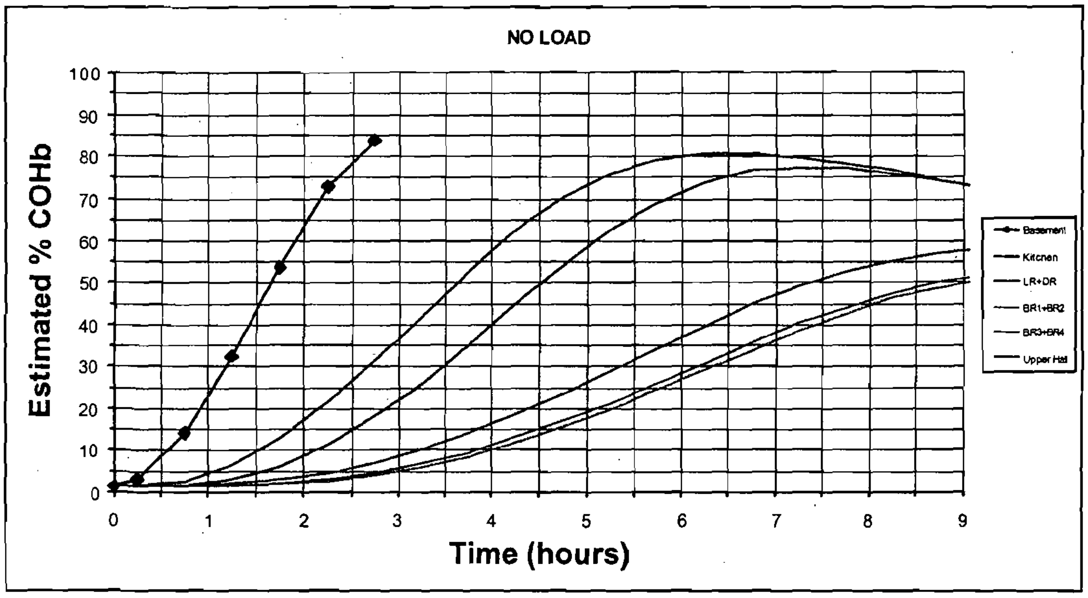
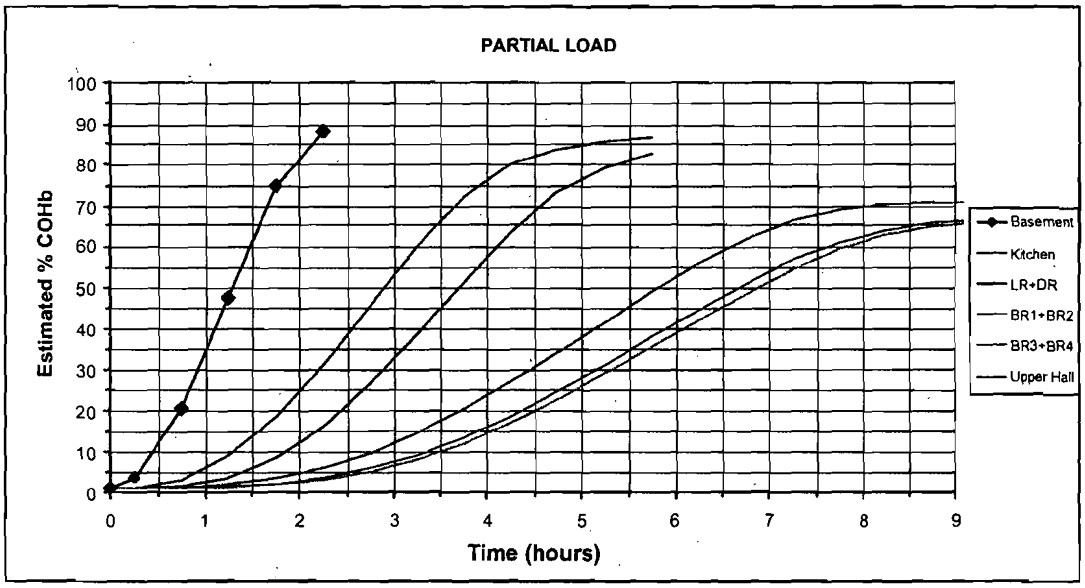
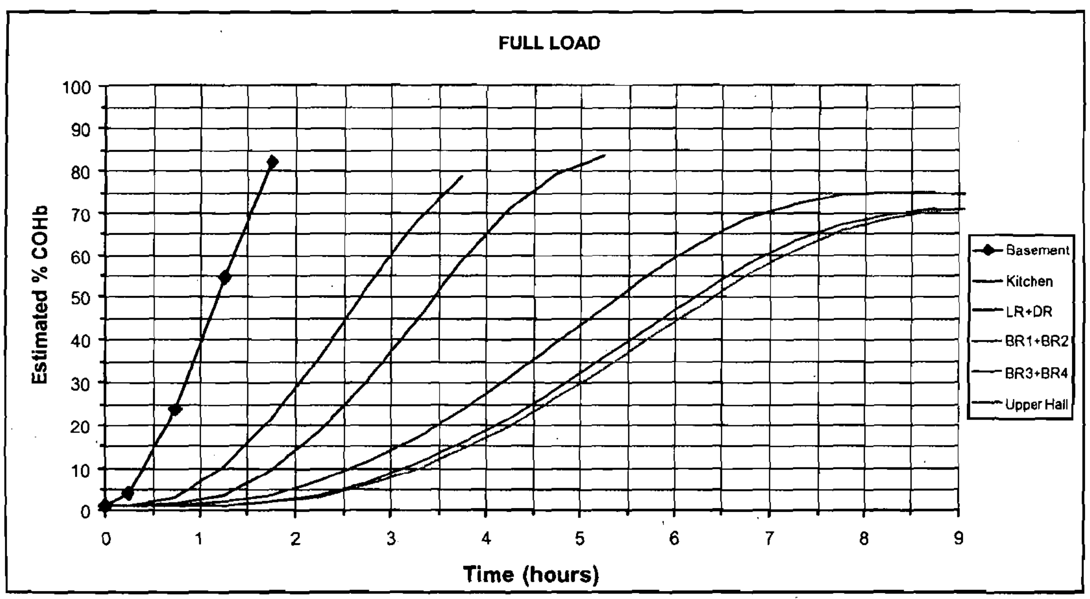
Appendix B1
Predicted COHb profiles by home location during operation of a 5.5 Kw generator in a basement:
Assumptions: No HVAC fan running: resting/low activity (6L/min RMV)

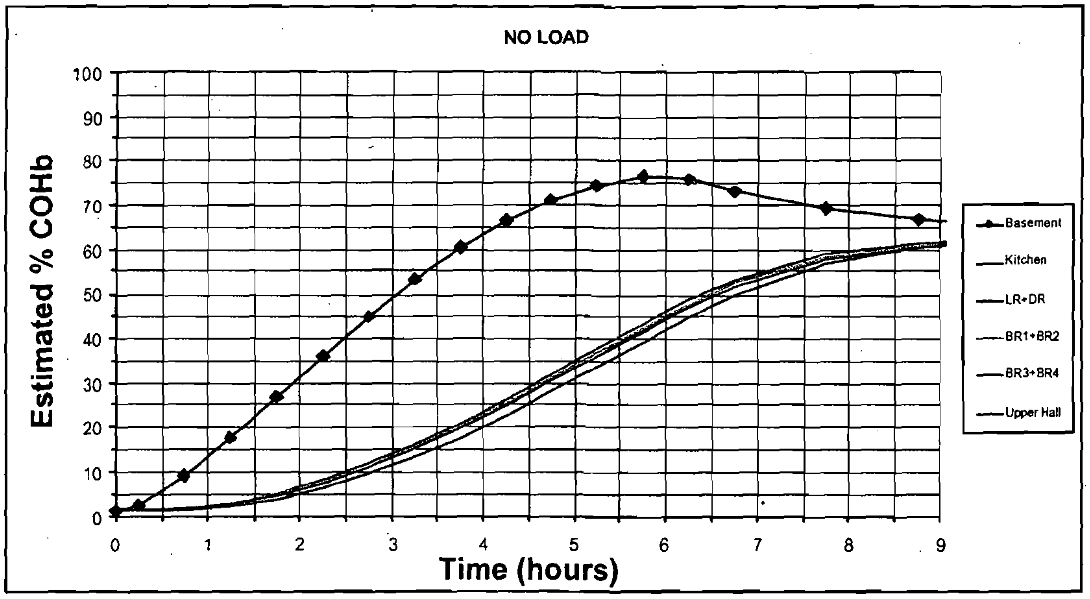


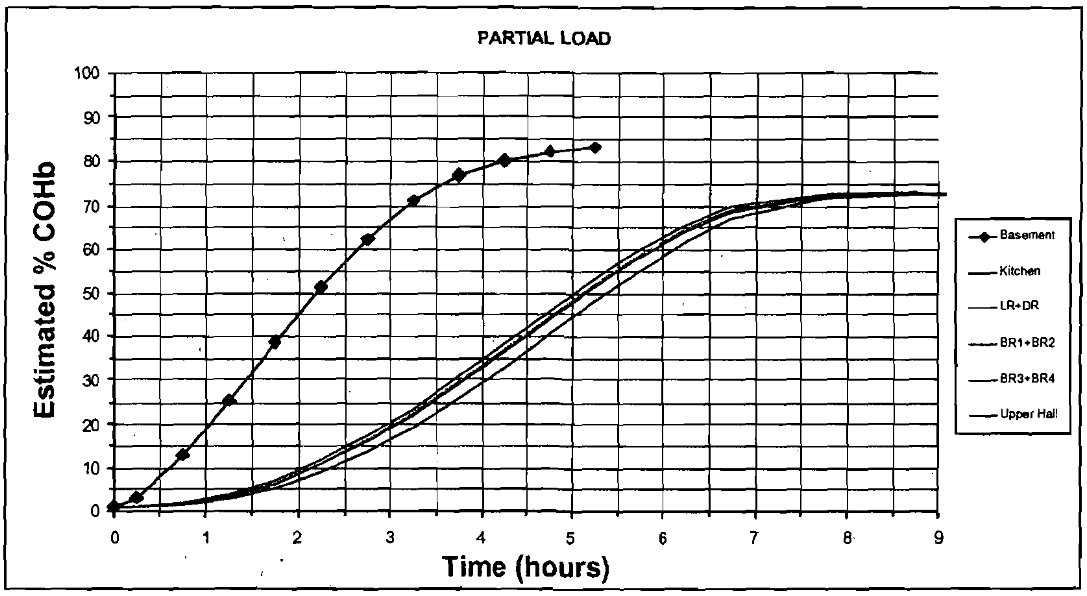



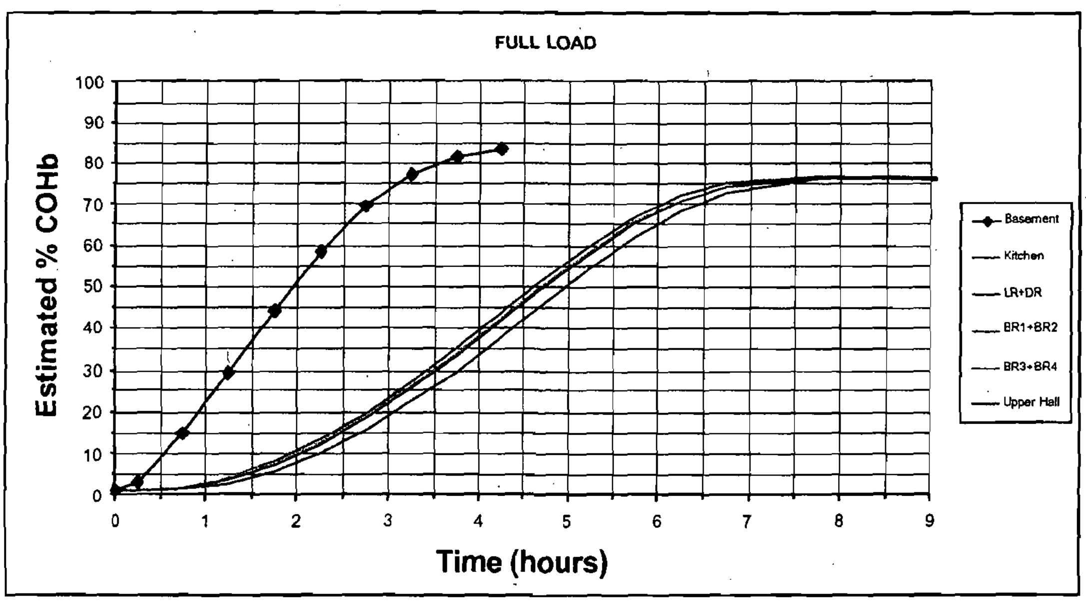



Appendix B2

Predicted COHb profiles by home location during operation of a 5.5Kw generator in a basement: Assumptions:with HVAC fan running: low/resting activity (6L/min RMV)

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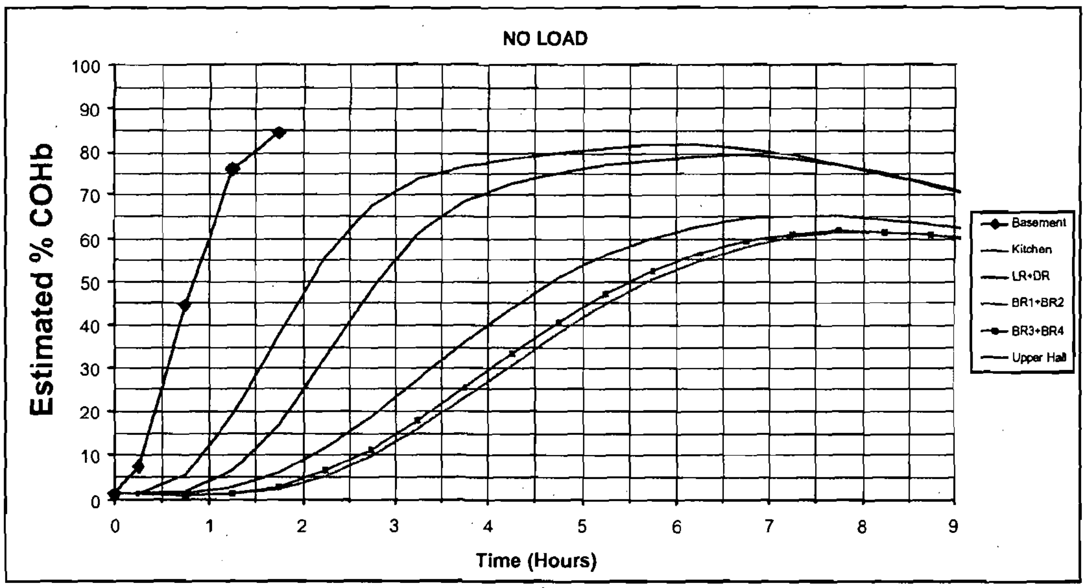
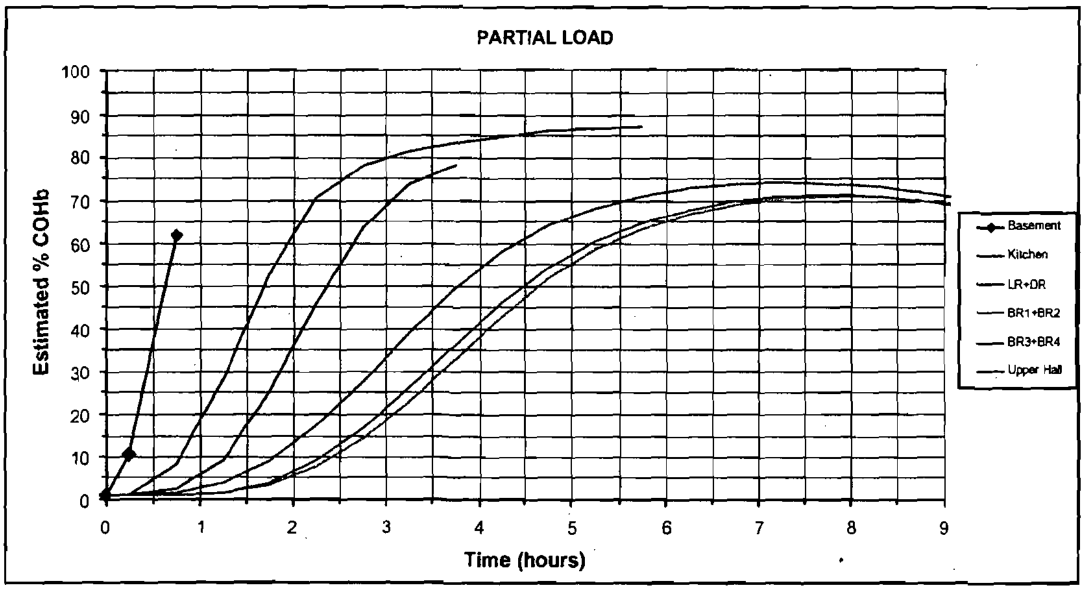
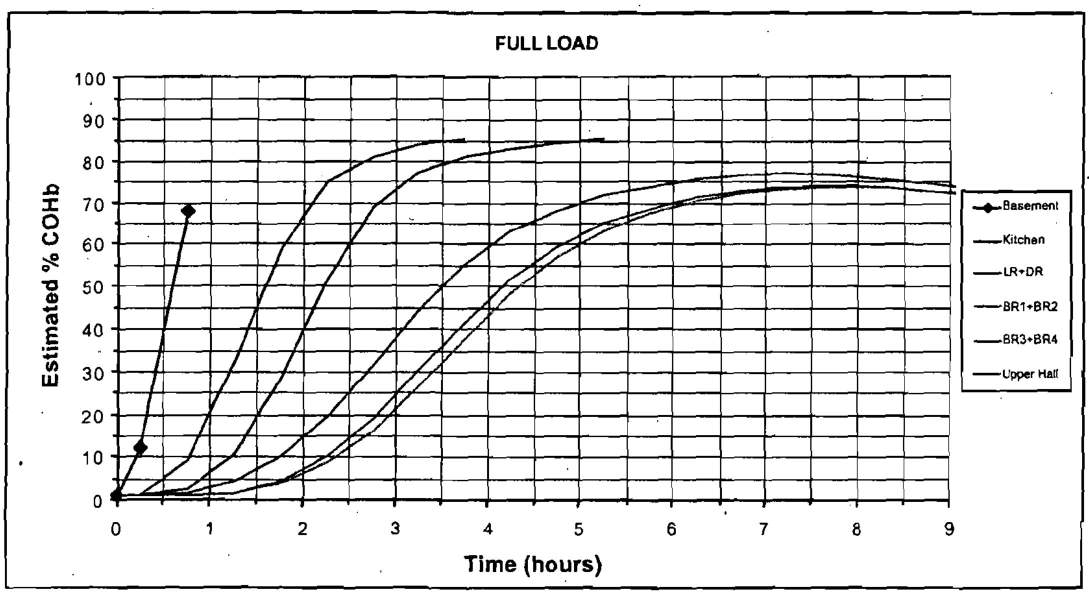
## Appendix B3

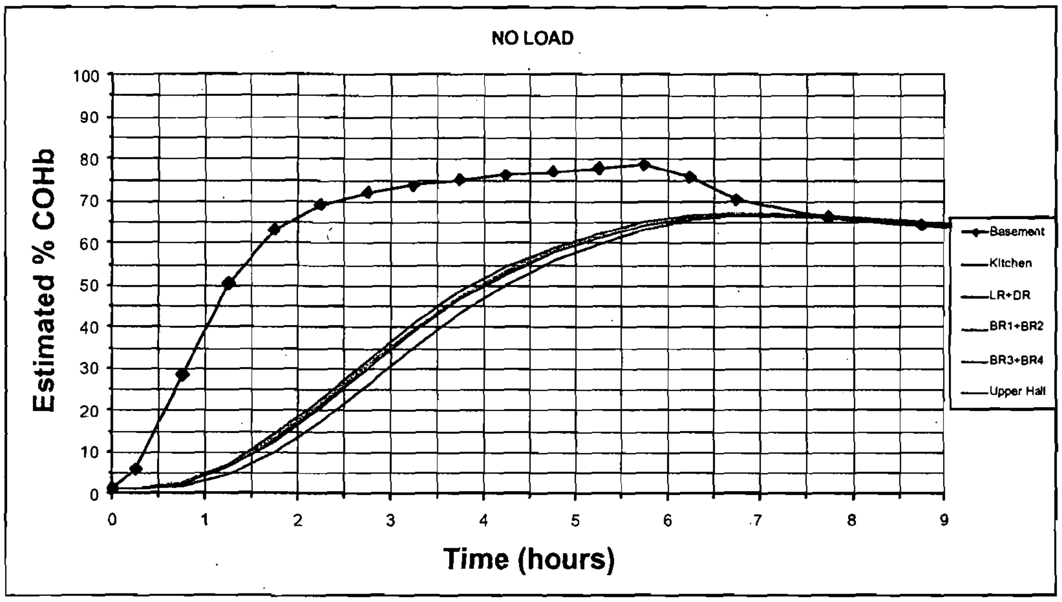
Predicted COHb profiles by home location during operation of a 5.5 Kw generator in a basement: Assumptions: No HVAC fan running: moderate activity (20L/min RMV)

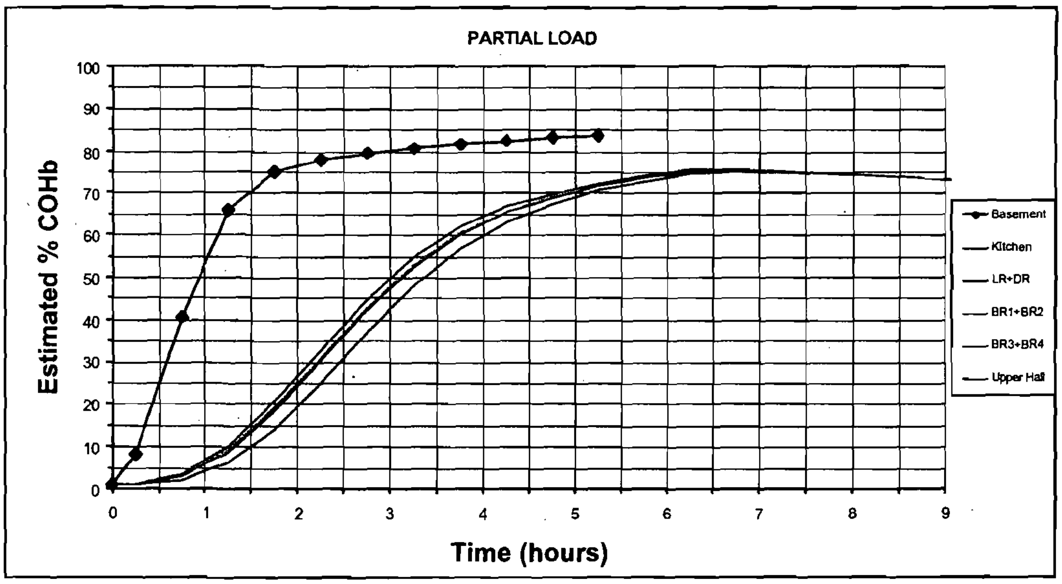


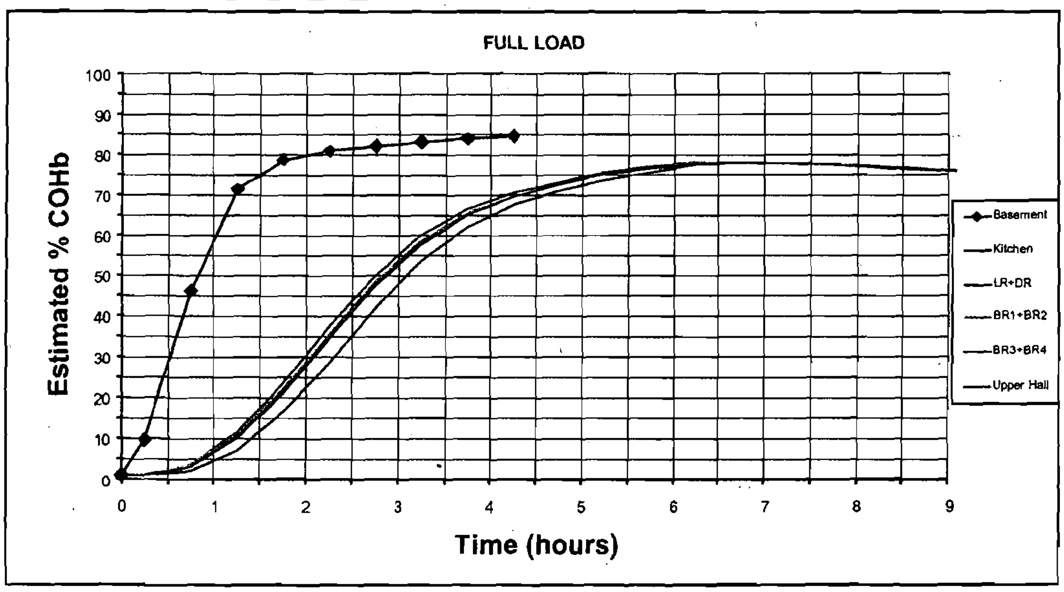



Appendix B4
Predicted COHb profiles by home location during operation of a 5.5Kw generator in a basement: Assumptions:with HVAC fan running: moderate activity (20L/min RMV)



# TAB G

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

**Memorandum**

Date: January 5, 2005

TO : Janet Buyer
ESFS

THROUGH: Russell Roegner, Ph.D., AED RR
Directorate for Epidemiology

FROM : Risana Chowdhury R.C.
EPHA

SUBJECT : NFIRS Data on Generators, 2002*

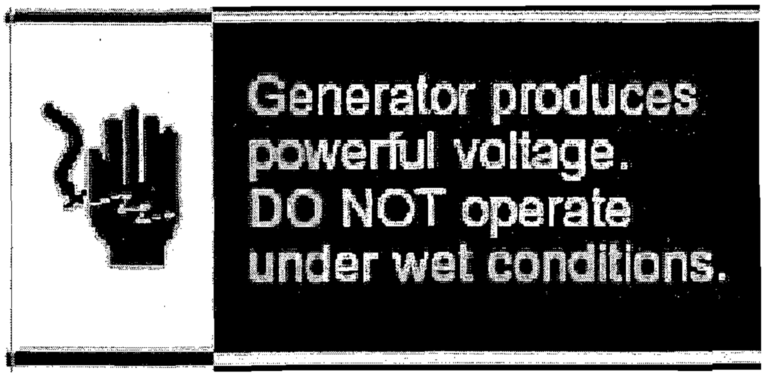
Based on the latest available data provided by the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's annual survey of fire losses, it is estimated that there were 100 fires involving generators in 2002. Associated with these fires, it is estimated that there were 10 injuries and $3.0 million in property and content loss. It is possible that these are underestimates since, in 2002, only 70% of the data was coded in the new NFIRS version 5.0 which allowed for the identification of generators as the equipment involved in ignition.

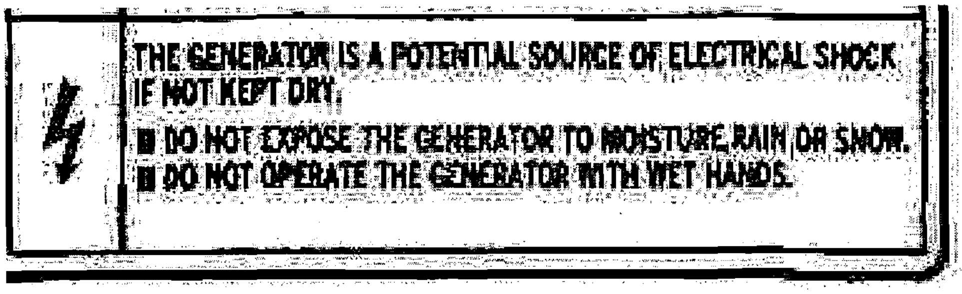
The estimates pertain to unintentional, residential structure fires, resulting in civilian injuries. The fire estimate is rounded to the nearest 100; the injury estimate is rounded to the nearest 10, while the property/content loss estimate is rounded to the nearest tenth of a million dollars.

* This analysis was prepared by the CPSC staff. It has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

# TAB H

Examples of warning language on generators concerning electrocution hazard:



# TAB I

## ⚠ WARNING

Failure to read and follow these instructions can result in death, bodily injury and/or property damage.

Read and follow operating instructions before running generator.

Engines emit carbon monoxide. DO NOT run in enclosed area.

Gasoline and its vapors are extremely flammable. Allow engine to cool at least 2 minutes before refueling.

Generator produces powerful voltage. DO NOT operate under wet conditions.

Transfer switch MUST be used when connecting generator to a building s electrical system.

Muffler area temperature may exceed 150 F. DO NOT touch hot parts.

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Enlarged; not actual size.

Check oil and fuel level. Disconnect entire electrical load from unit. Open fuel valve if so equipped. Adjust choke (prime) as necessary. Set engine switch to the ON, RUN, or START position. Pull starter rope with a fast steady pull (non electric start.) Adjust choke as unit warms up.

Remove entire electric load and let unit run for 2 minutes. Set engine switch to OFF or STOP position. Do not leave generator until it has completely stopped. Close fuel valve for storage or transport if so equipped.

Read and understand Operating Instructions before starting. Provide proper ventilation! Do not operate in a confined area due to danger of carbon monoxide poisoning! To prevent burns do not touch the exhaust system or engine until cool! Do not use in rain or snow! Electric shock may result and could be fatal! Connect to a suitable ground. Do not refuel in an enclosed area or while the engine is running. Allow the engine to cool for 2 minutes before refueling. Gasoline is extremely flammable and can be explosive! To avoid back feeding into utility systems, isolation of the residence electrical system is required. Before temporary connection of a generator to the residdance electrical system, turn off the main switch. Before making permanent connections, a double throw transfer switch must be installed to avoid electrocution or property damage, only a trained electrician should connect generator to residence electrical system. California law requires isolation of the residence electrical system before connecting a generator to the residence electrical system.

Vérifier les niveaux d'huile et de combustible. Débranche toute la charge électrique de l'appareil. Fermer la soupape d'arrêt de l'alimentation. Ajuster le volet de départ (amorcer si nécessaire). Régler le levier d'engagement à la poscon "ON" ou "RUN (marche). Tirer la corder de lancement d'un mouvement rapide. Ajuster le volet de depart tandis que l'appareil se réchauffe.

Retirer la charge électrique complète de générateur. Régler le levar d'engagement à "OFF" ou "STOP" (arrêt). Fermer la vanne de combustible pour range ou transporter.

Lire et bien comprendre la manuel de l'utilisateur avant de mettre l'appareil en marche. S'assurer d'une bonne ventilation! Ne pas faire fonctionner dans une endroit confiné àcause dudanger d'empoisonnement au monoxyde de carbone. Pour éviter les brulures, ne pas toucher le système s'échappement ou le moteur avant qu'il ne soit refroid! Ne pas utiliser sous la pluie ou la neige, un choc électrique peut-être mortel peut se produire! Brancher l'appareilà une masse appropriee. Ne pas faire le plein dans un endroit confine ou lorsque le moteur est en marche. Laisser le moteur refroidir 2 minutes avant de faire le plein. L'essence est extrmement inflammable et peut exploser! Pour éviter la réalimentation dans les systèmes de services publics, il faut isoler le système électrique de la résidence. Avant l'installation temporaire d'un générateur au système électrique résidentiel, arrêter l'interrupteur principal. Avant de faire des raccords permanents, on doit installer un commutateur converteur bipolaire. Pour éviter l'électrocution ou les dommages àla propriété, seul un électrician formé doit brancher le générateur au système électrique de la résidence. La loi de California exig l'isolation du système électrque résidentiel avant de raccorder un générateur au système électrique résidentiel.

Revise los niveles del aceite y del combustible. Desconecte completamente la carga de electricidad de la unidad. Abra la valvula de combustible si acaso hay. Ajuste el choke(cebar) como requiere. Ajuste el interruptor del motor en la posición de "ON"(en marcha) "START"(arranque). Tire la cuerda de arranque (si no hay arranque electrico). Ajuste el choke hasta que el motor caliente.

Desconecte completamente la carga de electricidad del generador. Ajuste el interruptor del motor en la posición de "OFF" (desconectado) "STOP"(parado). Cierre la valvula de combustible para almacenaje o transporte.

Lea y comprenda el manual para operarios antes de poner la unidad en marcha. Provease de ventilación apropiada. No haga funcionar en una zona encerrada, por causa del peligro de intoxicación por el monóxido de carbono! Para evitar las quemaduras, no toque la unidad ni el sistema de gases de escape hasta que esten enfriados! No haga funcionar bajo la lluvia ni la nieve. Una descarga electrica puede ser el resultado y puede ser fatal. Conecte la unidade apropiadamente a tierra. No rellene el depósito de combustible en una zona encerrada, ni cuando el motor este en marcha. Antes de rellenar el depósito de combustible, pare la unidad y deje enfriarse para 2 minutos. La bencina es sumamente inflamble y puedo ser explosiva! Para impedir la contra-alimentación hacia los sistemas de utilidad, es necesario aislar el sistema de electricidad de residencia. Antes de conectar temporalmente un grupo electrógeno al sistema de electricidad de residencia, desconecte el interruptor principal. Antes de hacer conexiones permanentes, es necesario instalar u conmutador de dos direcciones. Para evitar le electrocucion o daños materiales, unicamente un electriciasta calificado debe conectar el grupo electrógeno al sistema de electricidad de residencia las leyes de California exigen el aislamiento del sistema de eletricidad de residencia antes de conectar un grupo electrógeno al sistema de electricidad de residencia.

**HOT SURFACE CHAUDE SUPERFICIE CALIENTE**

Enlarged; not actual size.

| ⚠ WARNING | ⚠ WARNING |
|---|---|
| GASOLINE IS HIGHLY FLAMMABLE AND EXPLOSIVE. YOU CAN BE BURNED OR SERIOUSLY INJURED WHEN HANDLING FUEL.<br>■ STOP THE ENGINE AND KEEP HEAT,SPARKS,AND FLAME AWAY.<br>■ HANDLE FUEL ONLY OUTDOORS.<br>■ DO NOT FILL THE FUEL TANK ABOVE THE UPPER LIMIT LINE.<br>■ WIPE UP SPILLS IMMEDIATELY.<br>■ AFTER OPERATION,TURN THE ENGINE SWITCH AND FUEL TANK CAP LEVER TO THE "OFF" POSITION PREVENT FUEL LEAKAGE. | IMPROPER CONNECTIONS TO A BUILDING CAN ALLOW ELECTRICAL CURRENT TO BACKFEED INTO UTILITY LINES, CREATING AN ELECTROCUTION HAZARD.<br>■ CONNECTIONS TO A BUILDING MUST ISOLATE GENERATOR POWER FROM UTILITY POWER AND COMPLY WITH ALL APPLICABLE LAWS AND ELECTRICAL CODES. |
| CARBON MONOXIDE GAS IS TOXIC. BREATHING IT CAN CAUSE UNCONSCIOUSNESS AND EVEN KILL YOU.<br>■ AVOID ANY ENCLOSED AREAS OR ACTIVITIES THAT EXPOSE YOU TO CARBON MONOXIDE. | THE GENERATOR IS A POTENTIAL SOURCE OF ELECTRICAL SHOCK IF NOT KEPT DRY.<br>■ DO NOT EXPOSE THE GENERATOR TO MOISTURE,RAIN,OR SNOW.<br>■ DO NOT OPERATE THE GENERATOR WITH WET HANDS. |

Enlarged; not actual size.

# ⚠ WARNING

**Do Not Remove, Destroy, Or Cover This Label**

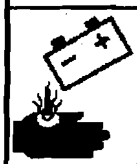
Read American National Standard Z49.1, "Safety In Welding, Cutting, and Allied Processes," From American Welding Society, 550 N.W. LeJeune Rd., Miami, FL 33126; OSHA Safety and Health Standards, 29 CFR 1910, from U.S. Government Printing Office, P. O. Box 371954, Pittsburgh, PA 15250.

**ELECTRIC SHOCK can kill.**
- Always wear dry insulating gloves.
- Insulate yourself from work and ground.
- Do not touch live electrical parts.
- Stop engine before installing or servicing.
- Keep all panels and covers securely in place.

**BATTERY EXPLOSION can blind and kill.**
- Shut off engine when servicing.
- Do not service near sparks or open flame.
- Wear face shield and rubber gloves.

**FUMES AND GASES can be hazardous to your health.**
- Keep your head out of the fumes.
- Ventilate area, or use breathing device.
- Read Material Safety Data Sheets (MSDSs) and manufacturer's instructions for materials used.

**ENGINE EXHAUST GASES can kill.**
- Use in open, well ventilated areas, or vent exhaust outside.



**BATTERY ACID can cause tissue damage.**
- Wear protective clothing and rubber gloves.
- Handle battery in up-right position.

**ARC WELDING can be hazardous.**
- Read and follow all labels and the Owner's Manual carefully.
- Only qualified persons are to install, operate, or service this unit according to all applicable codes and safety practices.
- Pacemaker wearers consult clinician — possible interference.
- Keep children away.

**WELDING can cause fire or explosion.**
- Do not weld near flammable material.
- Watch for fire; keep extinguisher nearby.
- Do not locate unit over combustible surfaces.
- Do not weld on closed containers.

**MOVING PARTS can cause injury.**
- Keep away from moving parts.
- Keep all doors, panels, covers, and guards closed and securely in place.

**ENGINE FUEL can cause fire or explosion.**
- Stop engine before fueling.
- Do not fuel while smoking or if near sparks or flames.
- Do not overfill tank; clean up any spilled fuel.

**ARC RAYS can burn eyes and skin; NOISE can damage hearing.**
- Wear welding helmet with correct filter.
- Wear correct eye, ear, and body protection.

# ! MISE EN GARDE

**UN CHOC ELECTRIQUE peut etre mortel.**
- Installation et raccordement de cette machine doivent etre conformes a tous les codes pertinents.

**SOUDAGE A L'ARC peut etre hasardeux.**
- Lire le manuel d'instructions avant utilisation.
- Ne pas installer sur une surface combustible.
- Les fils de soudage et pieces conductrices peuvent etre a la tension de soudage.

CAN/CSA W117.2-M87. "Safety In Welding, Cutting, and Allied Processes," published by the Canadian Standards Association, 178 Rexdale Blvd., Rexdale (Toronto), Ontario, Canada, M9W IR3.

211 297-B

Enlarged; not actual size.

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

## MEMORANDUM

June 18, 2002

**To:** Janet L. Buyer,
Project Manager, Small Engine-Driven Tools Project,
Division of Combustion and Fire Sciences, Directorate for Engineering Sciences

**Through:** Hugh McLaurin,
Associate Executive Director,
Directorate for Engineering Sciences

Robert B. Ochsman, Ph.D., CPE,
Division Director, Division of Human Factors,
Directorate for Engineering Sciences

**From:** Timothy P. Smith,
Engineering Psychologist, Division of Human Factors,
Directorate for Engineering Sciences

**Subject:** Human Factors Assessment for the Small Engine-Driven Tools Project

## INTRODUCTION

When fuels such as gasoline burn, they produce various chemicals including carbon monoxide (CO), a potentially lethal gas (NIOSH, CDPHE, CPSC, OSHA, & EPA, 1996). As a consequence, many people who have used tools with small gasoline-powered engines, such as generators, have experienced CO poisonings. Staff from the U.S. Consumer Product Safety Commission's Division of Human Factors (ESHF) has been asked to determine the effectiveness of current warning labels in addressing this hazard, and to determine what could be done to improve the effectiveness of warning labels in this situation.

## DISCUSSION

In general, warnings are only likely to be useful if the hazard, consequences, and appropriate safe behavior are previously unknown to those exposed to the hazard (Laughery & Wogalter, 1997). There have been many incidents of CO poisoning due to consumers not recognizing the danger of using small gasoline-powered engines indoors (NIOSH, et al., 1996). In addition, ESHF staff reviewed numerous in-depth investigations into incidents involving small engine-driven tools, and several are consistent with what one would expect if the consumer were not aware of the CO hazard posed by the tools.

Some incidents also appear to demonstrate consumer misunderstanding of CO, in general. For example, in one incident a consumer used a generator in the basement of his home due to a power outage. The consumer was not in the basement while it was in use, but later the consumer entered the basement, shut off the generator, and stayed inside the room. It is difficult to determine the extent to which the consumer was aware of the CO hazard associated with a running generator, but it is clear that the consumer failed to recognize the presence of a CO hazard after the generator had been shut off. This is not surprising since CO is colorless, odorless, and tasteless, and since the symptoms of CO overexposure—that is, headaches, dizziness, nausea, weakness, visual disturbances, changes in personality, or unconsciousness—could be easily mistaken for symptoms of other illnesses (NIOSH, et al., 1996). Therefore, consumers without prior knowledge of the hazard are unlikely to recognize overexposure when it occurs.

According to Earnest, Mickelsen, McCammon, and O'Brien (1997), some products that are equipped with small gasoline-powered engines have a warning stating that the product should be used only in well-ventilated areas. To better understand the warning information related to CO poisoning to which consumers are currently exposed, ESHF staff examined the on-product warnings present on different-model generators by visiting two large home-improvement stores. ESHF staff also examined three owner's manuals associated with different models of generators. Generators were the primary focus of these examinations since it appears that generators are involved with more CO poisonings than any other small engine-driven tool. While ESHF staff does not claim that the warning information examined encompasses all CO-related warnings present on small engine-driven tools and their manuals, the staff does believe they will provide a reasonable sample of the kind of information to which consumers may be exposed.

**Warning Conspicuity**

Most on-product warnings examined were on the top or side surface of the gas tank, which served as the top-most surface of each generator. Since the top surface of the tank is readily visible to the consumer, ESHF staff believes it is a good location for a warning label, in general. While most labels were consistent with ANSI Z535 (1998), some were of low contrast, used small type, and lacked a safety alert symbol, which made them less noticeable and more difficult to read. Sometimes this lack of contrast was due to the placement of a label with a black background onto a gas tank that was also colored black. Since all gas tanks examined were either red or black, labels with a white background for the message text would tend to be more conspicuous. The labels often included a great deal of safety information beyond warning about potential CO hazards, and the CO hazard was never the first message on any of the labels. As a consequence, some consumers may stop reading before getting to the CO-related information or may not read the label at all due to the amount of information presented. Some generators included a more concise label near the pull cord of the generator, but sometimes this label was not in plain view. The CO hazard is among the hazards described in this label, and its conciseness makes it more likely to be read by consumers if noticed. Label durability is also important for on-product warnings and directly affects conspicuity since a warning that does not withstand the elements may not be available to consumers when needed. For example, in one incident a consumer rented the generator involved, had no experience with its use, and was reportedly unaware of the need to ventilate the tool during use. An on-product label that warned of the generator's use in an enclosed area was essentially illegible because it was partially removed.

The owner's manuals examined by ESHF staff tended to include numerous warnings, many of which were grouped into a safety-like section. This can be useful for consumers who are looking for all safety information available on the product. However, consumers who use the manual may not necessarily be looking for safety information but may simply wish to know how to use the product. In addition, the number of warnings present in a safety section can be overwhelming, causing the consumer to simply bypass this information. One way to avoid this is to also embed warnings within the operating instructions where appropriate. Consumers—especially those who are unfamiliar with how generators operate—are very likely to check the operating instructions, yet only one of the reviewed generator manuals included a warning on the potential CO hazard within a section of this kind. Even that warning was placed after the final step rather than at the beginning of the sequence required for operation. Since a warning on the CO hazard tends to advise consumers on where or how to use the tool safely, it would be more appropriate to include this warning at the beginning of any operating instructions, possibly as the first step.

**Warning Comprehension**

The on-product warnings were often vague in describing the CO hazard and its consequences. Some identified the hazard as a "breathing hazard." This was sometimes reinforced through the use of a small pictorial of a person breathing gases or fumes. Some labels stated that the engine exhaust could "cause injury or death" or that "engines emit carbon monoxoide," but others only referred to the potential for "carbon monoxide poisoning" without further elaborating on the source of the CO. This lack of consistency makes it unclear exactly what information about the hazard consumers are eliciting from the on-product warnings. Consumers may understand that engine exhaust is dangerous but may not understand exactly what "carbon monoxide" is. Without an understanding of CO and its characteristics, consumers may believe they will be able to sense it if it approaches dangerous levels. This is somewhat reflected by some in-depth investigations that include statements about people "smelling" or not smelling CO, which is, in fact, odorless.

Information about the CO hazard and its consequences is often presented in greater detail within the owner's manuals. For example, according to one owner's manual the label placed on the generator itself described the CO hazard as, "Exhaust gas contains poisonous carbon monoxide." Within the manual, however, the potential CO hazard was described as "breathing exhaust" that "contains poisonous carbon monoxide, a colorless and odorless gas." This same manual also warned about running the generator "in an area that is confined, or even partially enclosed," which can cause the air being breathed to "contain a dangerous amount of exhaust gas." Other manuals provided additional details about CO in general, including the fact that it is odorless and invisible. ESHF staff believes it is important for warnings about the CO hazard, especially those within manuals, to identify the fact that CO is colorless, tasteless, odorless, and nonirritating, and that it can overcome a consumer without their perceiving it (NIOSH, et al., 1996). Advising consumers to look for the warning signs of CO overexposure may also be useful since the symptoms could be mistaken for symptoms of other illnesses such as colds, flu, or food poisoning (NIOSH, et al., 1996).

The warnings both on the generators and within the owner's manuals typically provided the same guidance on the steps consumers should take to avoid the CO hazard. In general, they instruct consumers to (1) provide proper ventilation and/or (2) not operate the generator in a confined or enclosed area. However, this advice is open to interpretation by the consumer. For example, does "confined" or "enclosed" mean *completely* confined or enclosed? The current language implies that using the generator indoors is acceptable as long as there is adequate ventilation or some other means of removing the exhaust fumes. Even if accurate, this begs the question of what constitutes proper or adequate ventilation. None of the on-product warnings examined by ESHF staff provided specific guidance, and only one of the manuals did: by piping exhaust gases "from enclosed areas." Would an open window or door also be sufficient? What if the consumer is running a fan? It is clear that some consumers believe opening a window or operating a fan provides sufficient ventilation (Earnest, et al., 1997; NIOSH, et al., 1996). Incidents involving generators provide further insight into consumers' perceptions of what constitutes good ventilation:

- The consumer used a generator in an attached garage with the door partially open.
- The consumer used a generator outside his trailer home.
- The consumer used a generator in an attached garage with the garage door open.
- The consumer used a generator in an attached garage with the garage door open and the generator just inside the door.
- A generator, blocked off with wood, was being used in the back partition of a trailer. The exhaust pipe of the generator was aimed towards a vent.
- The consumer used a generator inside a boat with the porthole open.
- The consumer used a generator inside his home after being warned by his friend not to use it inside. A fan was used to vent the fumes towards an open window.
- The consumer used a generator in the basement of his home for light to connect vent pipes to the generator. The pipes were reportedly not sealed, which caused CO to leak from them.

In every one of these incidents, one could argue that the consumer's behavior was consistent with the recommended behavior on most CO-hazard warnings. The resulting CO poisonings, however, suggest this behavior is not appropriate. So the question becomes, how should consumers actually be responding?

A study by Earnest, Mickelsen, McCammon, and O'Brien (1997) indicates that hazardous CO concentrations can develop within minutes of using a small gasoline-powered engine, and that extremely high ventilation rates would be necessary to reduce this hazard. Their recommendation is that these engines not be operated inside buildings or semi-enclosed spaces at all, even if some ventilation is provided. This recommendation is consistent with an alert produced by several government agencies that states people should not use gasoline-powered engines or tools inside buildings or in partially enclosed areas unless the engines can be located outside and away from air intakes (NIOSH, et al., 1996). Earnest, et al. (1997) also recommend that people be informed that opening windows and doors or operating a fan does not provide sufficient ventilation. ESHF staff believes this is reasonable and believes that it would be possible to reword current warnings based on the above recommendations so they provide more clear and explicit guidance on proper avoidance behavior.

**Consumer Motivation**

Even a warning that provides accurate advice and is capable of being followed by consumers will be of no use if consumers do not actually choose to follow that advice. Research indicates that two of the most important factors in determining the extent to which people will be motivated to read and comply with warnings are the cost of compliance and the cost of noncompliance (Laughery & Wogalter, 1997; Sanders & McCormick, 1993). To motivate people to follow the advice of the warning, the consumers' perceived cost of compliance must be less than the perceived cost of noncompliance.

Complying with the CO warning on a small engine-driven tool would require consumers to keep the product outdoors and away from air intakes during use. There may be several factors that increase the perceived cost of carrying out this action. Some may seem rather trivial (e.g., keeping a generator outside would require the consumer to have a fairly lengthy extension cord), but will still have some impact on the likelihood of consumers following the warning's advice. Some factors are not trivial at all and are likely to have a significant impact. For example, generators often include electrocution warnings that instruct consumers to behave in a way that may conflict with the behavior necessary to avoid the CO hazard. One owner's manual states that the consumer should not expose the generator to moisture, rain, or snow, and should "not let the generator get wet." An on-product warning for that same generator warns the consumer that "using the generator in the rain, snow, or near water can lead to death from electrical shock," and that consumers should, "keep generator dry." Another manual also states that the generator should not be used in wet or damp conditions. Depending on the weather conditions at the time the generator is needed, consumers may find it difficult to abide by the instructions given in both the CO and electrocution warnings. For example, in one incident a generator was used in an attached garage; the consumer was aware of the need for ventilation, but left the garage door partially closed because it was raining out at the time. In fact, consumers are likely to borrow or rent generators during inclement weather conditions since those conditions are often the very cause of the power outage that precipitates the use of a generator. The only way to address this conflict may be to redesign generators to permit their exposure to rain or other poor weather conditions during use. But even if this were done, some consumers may still choose not to keep the generator outside during use simply so they can avoid exposing themselves to those same weather conditions. Other perceived costs of complying with the warning may include the generator being stolen—two incidents indicate this was a significant factor in the decision to bring the generator inside—or the embarrassment associated with having the power shut off due to nonpayment. It is unclear what, if anything, could be done to encourage consumer compliance with the warning in these cases. The only way to address this concern may be to increase the perceived cost of noncompliance (i.e., of not following the advice of the warning) so it outweighs this concern. This is discussed below.

The cost associated with not following the warning's advice typically corresponds to an increased exposure to the hazard. Therefore, influencing a consumer's behavior demands that use of the product in any way contrary to the advice in the warning be perceived as very hazardous.

Since consumers' risk perceptions associated with consumer products tend to be based almost entirely on the severity of potential injury rather than the likelihood of injury (Laughery & Wogalter, 1997), it is necessary for the potential consequences associated with the CO hazard to be very clear to consumers. This may be addressed through proper warning language, as discussed earlier in this memorandum.

## CONCLUSIONS & RECOMMENDATIONS

Incidents involving CO overexposure and poisoning with small engine-driven tools indicate that some consumers do not recognize the CO hazard posed by the tool, and that some who do recognize the hazard may not understand the characteristics of CO. One way to improve consumer awareness of the hazard is to make the warning labels associated with the hazard more conspicuous. ESHF staff examined sample generators and generator owner's manuals. Based on these examinations, the staff recommends that on-product warning labels be consistent with ANSI Z535, and that warnings within owner's manuals be embedded within the operating instructions. In addition, warnings—especially on-product warnings—must be more explicit in describing the hazard (e.g., source, causes, characteristics of CO).

ESHF staff believes a great source of confusion with current generator warnings is the guidance offered on how to avoid the CO hazard. Current guidance on the product and within the owner's manuals is typically twofold: (1) do not use in a confined or enclosed space, and (2) provide proper ventilation. Both are open to interpretation by the consumer. In fact, some incidents indicate that the consumer knew ventilation was necessary when using generators, and that the consumer responded in ways that were consistent with what is currently recommended in the warning labels; yet CO overexposure still occurred. Since research suggests that the use of generators in even partially enclosed spaces is unsafe, ESHF staff believes warning labels must inform consumers that certain responses (e.g., opening a window, using a fan) do not provide adequate ventilation, and must instruct consumers to keep generators outdoors and away from air intakes during use. The latter recommendation, however, is in conflict with generator's electrocution warnings, which instruct consumers to keep the generator dry and out of damp conditions. Therefore, it would be necessary to resolve this conflict before specific language could be recommended regarding CO hazard avoidance behavior. In addition, some consumers may ignore the warnings' advice out of embarrassment (e.g., not wanting others to know that their power has been shut off) or to prevent the generator from being stolen.

## REFERENCES

American National Standards Institute. (1998). *American National Standard: Product Safety Signs and Labels (ANSI Z535.4-1998)*. Rosslyn, VA: National Electrical Manufacturers Association.

Cushman, W.H. & Rosenburg, D.J. (1991). *Human Factors in Product Design*. Amsterdam: Elsevier. 301–303.

Earnest, G.S., Mickelsen, R.L., McCammon, J.B., & O'Brien, D.M. (November 1997). "Carbon Monoxide Poisonings From Small, Gasoline-Powered, Internal Combustion Engines: Just

What Is a 'Well-ventilated Area'?" American Industrial Hygiene Association Journal. 58: 787–791.

Laughery, K.R. & Wogalter, M.S. (1997). "Warnings and Risk Perception." In Salvendy, G., Ed. *Handbook of Human Factors and Ergonomics*. New York: John Wiley & Sons, Inc. 1175–1195.

National Institute for Occupational Safety and Health (NIOSH), Colorado Department of Public Health and Environment (CDPHE), U.S. Consumer Product Safety Commission (CPSC), Occupational Safety and Health Administration (OSHA), & U.S. Environmental Protection Agency (EPA). (November 1996). *Alert: Preventing Carbon Monoxide Poisoning from Small Gasoline-Powered Engines and Tools*. DHHS (NIOSH) Publication No. 96–118.

Sanders, M.S. & McCormick, E.J. (1993). *Human Factors in Engineering and Design*. New York: McGraw-Hill, Inc. 668–684.

# TAB J

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

# MEMORANDUM

May 22, 2003

**To:** Janet L. Buyer
Project Manager, Small Engine-Driven Tools Project
Division of Combustion and Fire Sciences, Directorate for Engineering Sciences

**Through:** Hugh M. McLaurin
Associate Executive Director, Directorate for Engineering Sciences

Erlinda M. Edwards
Director, Division of Electrical Engineering
Directorate for Engineering Sciences

**From:** Andrew M. Trotta
Electrical Engineer, Division of Electrical Engineering
Directorate for Engineering Sciences

**Subject:** Weatherproof Portable Engine-Generators

This memorandum covers issues related to weatherproofing of portable engine-generator sets. For the purposes of this report, an engine-generator is defined as an electric power generator that employs a gasoline-fueled internal combustion engine as its mechanical rotational energy source. Generator output may include a variety of voltage configurations, including 120/240 volts, 60 Hz as it is typically configured in U.S. residential power systems. Applications of portable engine-generators include areas where electric power is unavailable or as backup electrical power when utility power is down. At the present time, there is no industry voluntary safety standard for portable engine-generators, but Underwriters Laboratories (UL) is in the process of publishing the first edition of a standard, UL 2201, *Standard for Portable Engine-Generator Assemblies*. The February 2003 draft version of UL 2201 was reviewed for this assessment. There is a standard for installed engine-generators, UL 2200, *Standard for Stationary Engine Generator Assemblies*, which was reviewed for applicability to the issue of weatherproofing.

Engine-generators that employ internal combustion engines produce a significant amount of carbon monoxide (CO), and therefore they must be used outdoors in a well-ventilated area, to prevent accumulation of dangerous levels of CO in enclosed spaces where people have access. Contrarily, most portable engine-generator sets are not suitable for use in rain because of the risk of electric shock. This situation is further complicated because severe weather conditions producing precipitation, such as thunderstorms, may result in the types of extended power outages in which people need to use their portable generators. A user could then be faced with a decision of prioritizing the risk of carbon monoxide poisoning versus electric shock. Part of the technical solution to address this problem would be to require portable generators to be weatherized to permit their use outdoors while precipitation is falling. The purpose of this memorandum is to discuss issues related to this option.

## DISCUSSION

Portable engine-generators are available in a variety of sizes, ranging in output power from about 900 to 10,000 watts (W). The basic components are a gasoline engine, electric generator and power distribution panel (receptacle outlets and circuit breaker, if included), as shown in Figure 1. These components are assembled in a frame or enclosure. Figure 2 shows three examples of different-sized portable generators – 900 W, 1,500 W and 5,500 W. These sample generators were purchased as part of the Small Engine-Driven Tools Project.

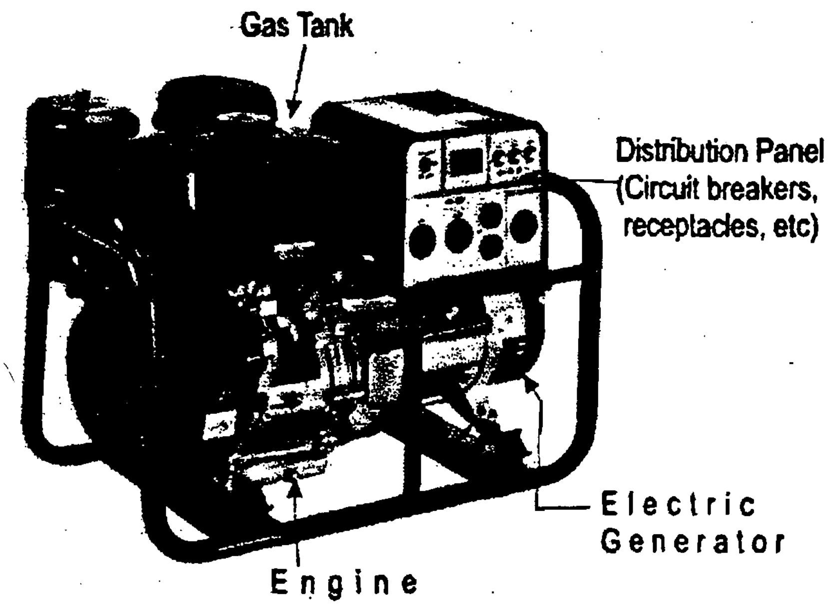



Figure 1. Typical engine-generator configuration.

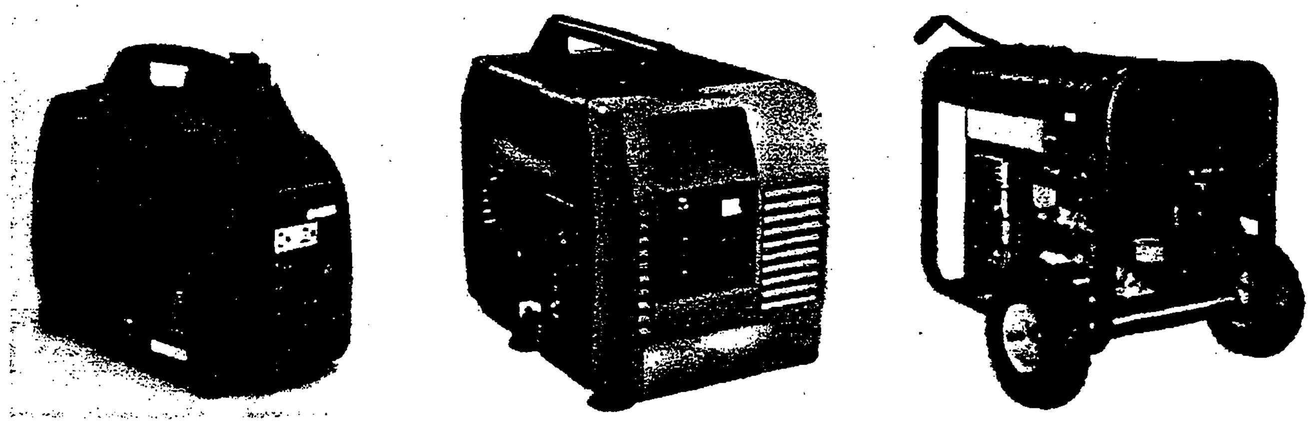


Figure 2. Portable Engine-Generators (L to R): 900 W unit (1.4 $ft^3$, 29 lbs.), 1500 W unit (2.0 $ft^3$, 68 lbs.) and 5500 W unit (7.5 $ft^3$, 148 lbs.); all weights exclude gasoline.

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In general, the primary selection criterion for a generator is power capacity based on what appliances or electrical equipment (also generally referred to as loads) are expected to be supplied. Providing backup power to essential loads (e.g., a few lights, refrigerator, television, space heater, microwave, and a fan) in an average size house requires a generator in the range of 3,500 to 5,500 W. Powering a number of convenience items or a high wattage load (heat pump, central air or an electric oven) easily pushes the capacity requirement to 10,000 W. Small generators, in the 1,000 W range, are used for supplying power to a specific load, often where electric power is unavailable, e.g., a pitching machine used in the middle of a baseball field. However, provided the connected load does not exceed the capacity of the generator, any generator with the proper output voltage could be used in any application, particularly in an emergency situation.

Portable generators have receptacle outlets for connecting load equipment to the generator. This includes standard 15 ampere (A)/20 A, 120 volt (V) grounded duplex receptacles and circular four-socket 120/240 V grounded receptacles (if the generator supplies 240 V). Appliances and electrical equipment can be plugged directly into the generator, but often loads are connected via an extension cord. Another way of supplying loads, particularly for back-up power applications, is connecting the generator output to the household branch circuit wiring via power transfer equipment intended to segregate the house wiring from the utility. Also, custom power cords are available with male plugs on each end. This allows the user to connect the generator output into a branch circuit receptacle and backfeed the household wiring. This is an extremely inadvisable practice as it presents a shock risk to utility workers and bypasses some of the household circuit protection devices.

The primary hazard related to outdoor use of engine-generators is electric shock. Electric shock occurs when a person contacts a live electrical circuit and current flows through the parts of the body that complete the circuit. Contact between a line conductor and ground is called a ground fault. This is shown graphically in Figure 3.

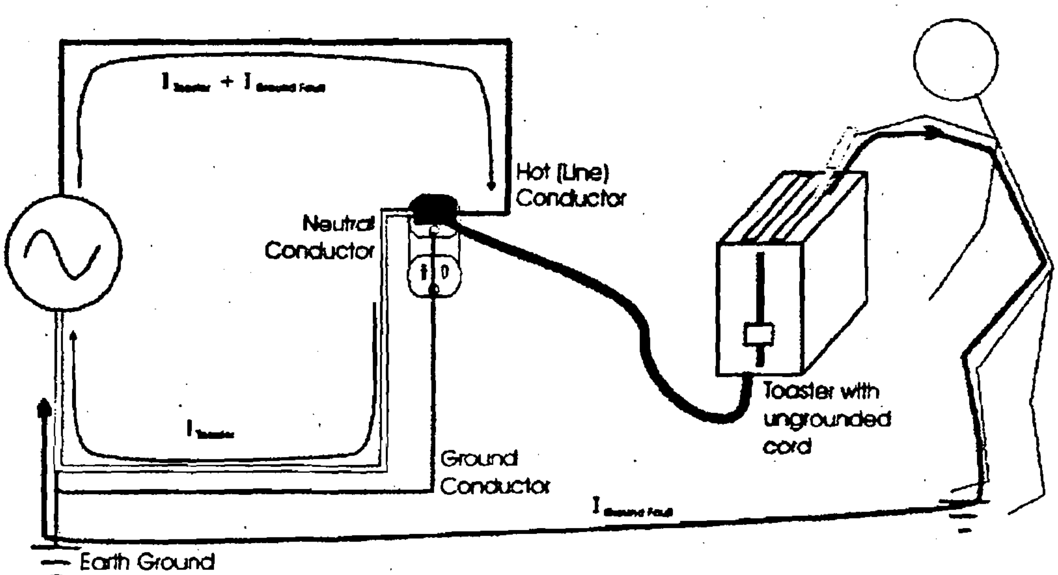



Figure 3. Schematic depiction of a ground fault in a grounded two-wire system supplying a two-wire unground appliance.

The severity of electric shock ranges from minimal sensation to electrocution, depending on a number of factors, including the magnitude of the current (as a function of the applied voltage) and the part of the body through which the current flows.

According to UL 2200, for an outdoor-use unit where wet contact is likely, a live part is not a risk of shock if the voltage of the part is below 15 $V_{rms}$ (21.2 V, peak).[1] For an indoor-use unit (wet contact not likely), the maximum voltage of live parts before a shock risk is defined is 30 $V_{rms}$ (42.4 V, peak). A portable engine-generator for residential use produces voltages of 120 V/240 V and, as such, possesses a potentially lethal shock risk. Although this risk exists even in the absence of rain, it is amplified during inclement weather because rain water may compromise the insulation systems of components such as power cords, electrical equipment and human skin, and the abundance of water reduces ground resistance.

The risk of shock may exist whether the generator is grounded or not, as illustrated in the two fault current paths shown in Figure 4.

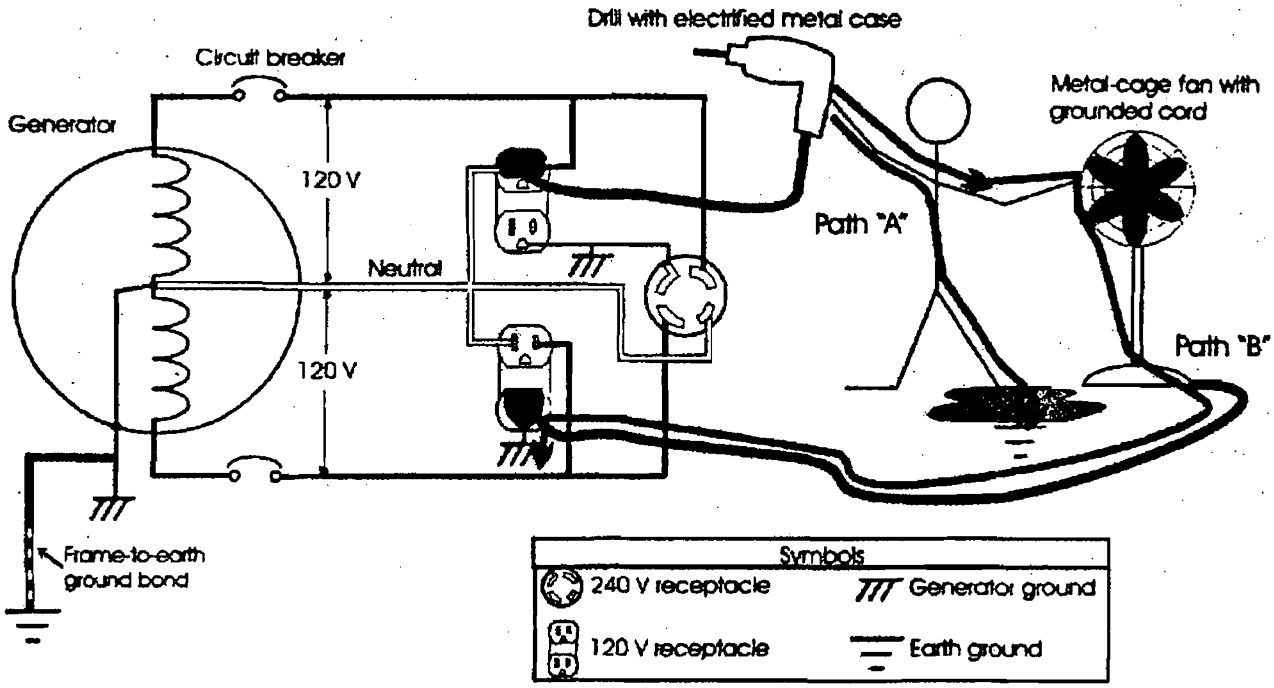



Figure 4. Graphical schematic of typical engine-generator set-up, showing alternate paths for electric shock. Path A depends on the user and generator being grounded, while Path B shows a leakage current path that does not require the generator to be grounded.

Path A shows the fault current flowing from a faulty drill through the user, who is grounded by a puddle of water, through earth ground and back to the grounded generator frame, which is tied to

[1] RMS is the root mean square value, which is used to describe the effective value of a sinusoidally-varying signal. For a pure sinusoidal waveform, the RMS value is the peak divided by the square root of 2. Unless otherwise noted, alternating current (AC) values are rms.

the neutral. This fault current path relies on both the generator and user being grounded. Path B shows the shock current flowing from the faulty drill through the user, through the metal case of the fan, through the power supply cord ground conductor to the receptacle ground, which is tied to the neutral conductor. Ground current path B does not rely on the generator being grounded to shock the user.

According to Article 100 of the 2002 *National Electrical Code*,[2] weatherproof is defined as equipment "constructed or protected so that exposure to the weather will not interfere with successful operation." The definition also indicates that, "rainproof, raintight or watertight equipment can fulfill the requirements of weatherproof where varying weather conditions other than wetness, such as snow, ice, dust or temperature extremes are not a factor." Requirements for outdoor use of portable generators are not included in the draft version of UL 2201. However, Sections 64 through 67 of UL 2200 include requirements for stationary generators intended for outdoor use. Basically, units listed for outdoor use must satisfy construction requirements to protect the unit against outdoor exposure and performance requirements to ensure the unit's exposure to rain does not result in conditions that could lead to a risk of electric shock. A stationary generator enclosure defined as raintight must prevent entrance of water during the rain test, while a rainproof enclosure must not permit live parts to get wet or permit entry of water above the lowest live part.

Using UL 2200 as a framework, development of outdoor-use requirements for portable generators should start with corrosion protection for vital parts and implementation of a raintight or rainproof enclosure for shock protection. As Figures 1 and 2 show, portable generator construction is very diverse – some are largely enclosed while others simply have an open frame on which the components are supported. Despite this diversity, it intuitively appears that a raintight or rainproof enclosure could be implemented, but it is not clear how this would impact other factors like size, cost and operability (e.g., a decreased ambient operating temperature range from a more airtight enclosure).

One major difference between portable and stationary generators is that output connections on portable engine-generators are made with plugs. Stationary generators have their output circuits hard-wired or permanently connected to the installed building wiring. Therefore, the output connections to a portable generator must be readily accessible by the user while the output connections of a stationary generator may be fully enclosed to prevent exposure from rain. This presents a particular problem for weatherproofing of portable generators.

There are some portable generator models that incorporate a cover for the power distribution panel to protect the outlets from water exposure. However, these covers are flat and do not provide coverage when a receptacle is in use. Since 1999, the *NEC* [410-57(b)(1) in 1999 and subsequently 406.8(B)(1) in 2002] has included requirements for receptacles installed outdoors in wet locations to have an enclosure that is weatherproof whether or not the attachment plug is inserted. Although this requirement is not applicable to a generator, these covers are now

[2] The *National Electrical Code* is a widely adopted code that establishes requirements for safe electrical installations. The *NEC* is revised every three years by a consensus committee process based on proposals from the public at large. Local jurisdictions adopt the NEC in part or in its entirety and local authorities, usually electrical inspectors, enforce these adopted provisions accordingly.

readily available in a number of different configurations and materials (e.g., polycarbonate and cast aluminum).

Figure 5 shows examples of the two basic types of weatherproof receptacle covers, one that is suitable for use whether or not a plug is inserted and the other that is weatherproof only when the cover is closed. Figure 5 also shows that an in-use weatherproof cover extends several inches beyond the face of the receptacle. This would extend the profile of some generators and could expose the cover to impact forces as the user transports the generator. There are impact resistance requirements for portable engine-generator enclosures in UL 2201 and plastic covers in UL 514C - *Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers*, but they are different than those proposed in the draft version of UL 2201. The most appropriate requirements for application of these covers on portable generators would need to be selected.

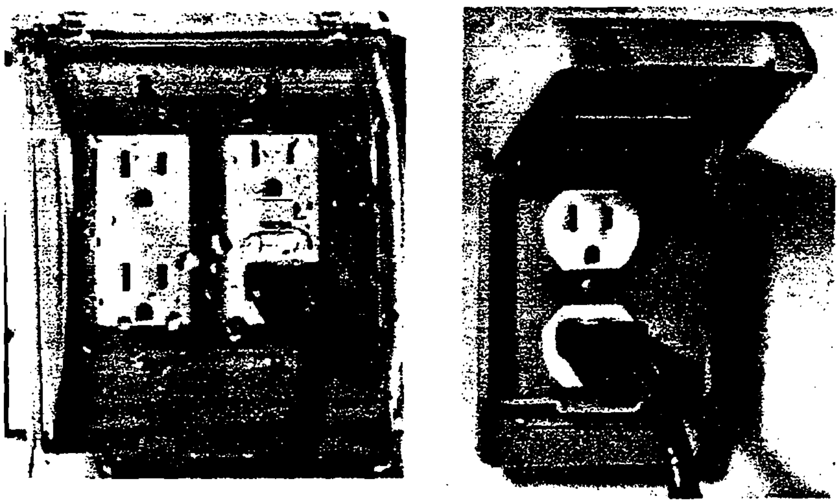


Figure 5. Examples of weatherproof covers. The cover on the left is weatherproof when in-use while the cover on the right is weatherproof only when closed.

An invaluable safety device to prevent electrocution is the ground fault circuit interrupter (GFCI). A GFCI looks for a differential between the line and neutral current, as would occur with a ground fault (as depicted in Figures 3 and 4). When the difference exceeds 0.005 amperes, the GFCI trips and opens the circuit. Ground fault circuit interrupters can be incorporated into receptacles, circuit breakers and power cords.

Recognizing the increased risk of electric shock from use of electrical equipment outdoors, the *NEC* has required GFCI protection for outdoor receptacles at dwelling units since 1973. Also, Section 15 of the draft version of UL 2201 proposes that all 120 volt and 120/240 volt outlets be ground-fault protected. However, a limited review of available generator models showed that very few portable engine-generator models have 120 V GFCI receptacles for shock protection. The review did not reveal any generators that included GFCI protection for their 240 V receptacles.

By itself, GFCI protection of all outlets does not constitute complete weatherization. The UL 2201 requirement for GFCI protection for all outlets only offers shock protection to users for loads that are plugged into the generator. Additional weatherproofing requirements to prevent wetting of live electrical parts and accumulation of water within the chassis are needed in addition to GFCI protection to provide complete shock protection for use of a generator in inclement weather.

One other issue related to portable engine-generators is the portability itself. While it appears that it may be possible (while not necessarily feasible) to weatherproof a portable generator through incorporation of a raintight or rainproof enclosure, in-use weatherproof receptacle covers and GFCIs, it is difficult to account for all possible locations in which a generator could be placed. For example, areas that are normally dry could be subject to significant puddling or channeling of water in heavy or prolonged rainfall. Some generators that are physically small (the first two generators in Figure 2 are only about 16" high) could become flooded from standing water (UL 2200 requirements do not address standing water).

## CONCLUSIONS

Presently, portable gasoline-fueled engine generators are not constructed to permit their use outdoors during inclement weather. This creates confusion for users, who cannot place the units indoors because of the significant levels of carbon monoxide emitted by the gasoline engine. Weatherproofing portable-engine generators to permit their use outdoors during inclement weather appears to be an attractive strategy to eliminate this confusion and the potential risk of electric shock associated with their outdoor use.

There is no industry voluntary safety standard for portable engine-generators, but UL is in the processing of adopting a standard, UL 2201, *Standard for Portable Engine-Generator Assemblies*. However, the draft version of the standard does not include requirements for weatherproofing. The standard for stationary generators, UL 2200, includes requirements for outdoor use. Using UL 2200 as a framework for outdoor-use requirements for portable generators, it appears that weatherproofing portable generators would include a raintight or rainproof enclosure, in-use weatherproof receptacle covers and ground fault circuit protection for all receptacles.

A raintight or rainproof enclosure appears to be achievable except that the connection of equipment to the generator output is significantly different for portable generators. Portable generators have output receptacles that permit electrical equipment to be quickly and easily connected and disconnected. As such, a portable generator distribution panel requires ready access, which would require covers that weatherproof the receptacles even with a plug inserted. The draft version of UL 2201 already includes requirements for GFCI protection for all receptacles, so this is at least one weatherization requirement that is already being addressed by the draft standard.

Options to address this issue include:

- Conduct a follow-up study to assess feasibility of modifying portable generator designs to incorporate weatherproofing
- Propose revisions to UL 2201 to require all portable engine-generators to be weatherproof
- Present issue to the Standards Technical Panel for UL 2201 for resolution

**REFERENCES**

National Fire Protection Association (2002). *National Electrical Code (NFPA-70)*. Quincy, MA: National Electrical Manufacturers Association.

*Standard for Portable Engine-Generator Assemblies* - UL 2201, draft version of 1st Edition, February 2003 was available for review, Underwriters Laboratories, Northbrook, IL

*Standard for Stationary Engine Generator Assemblies* - UL 2200, 1st Edition, September 1, 1998, Underwriters Laboratories, Northbrook, IL

*Overcurrents and Undercurrents Electrical Safety Advances through Electronics*, 2000, Earl W. Roberts, Reptec, Mystic, CT

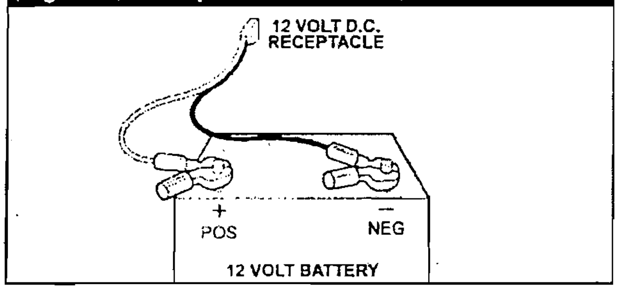
# TAB K

■Pages from owner's manual of currently available portable generator regarding cold weather operating instructions



[redacted]

Figure 8 — Battery Connections




7. Start engine. Let engine run while battery recharges.
8. When battery has charged, shut down engine

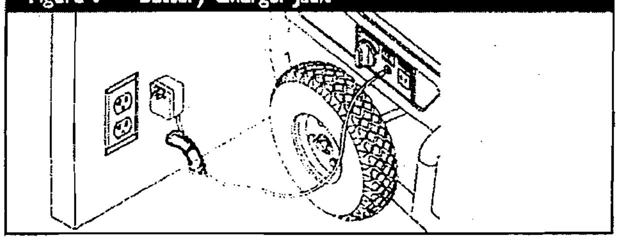
**NOTE:** Use an automotive hydrometer to test battery state of charge and condition. Follow the hydrometer manufacturer's instructions carefully. Generally, a battery is considered to be at 100% state of charge when specific gravity of its fluid (as measured by hydrometer) is 1.260 or higher.

## How to Use the Battery Charger

Use battery float charger jack to keep the starting battery charged and ready for use. Battery charging should be done in a dry location, such as inside a garage.

1. Plug charger into unit's "Battery Float Charger" jack, which is located on starter switch panel (Figure 9). Plug battery charger into a 120 Volt AC wall receptacle.

Figure 9 — Battery Charger Jack



2. Unplug charger from unit and wall outlet when generator is being started and while in operation.
3. Keep charger plugged in when generator is not in use to prolong battery life. The charger has a built in float equalizer and will not overcharge battery, even when plugged in for an extended period of time.

**IMPORTANT:** See "Battery Maintenance" on page 16 for additional information.

# COLD WEATHER OPERATION

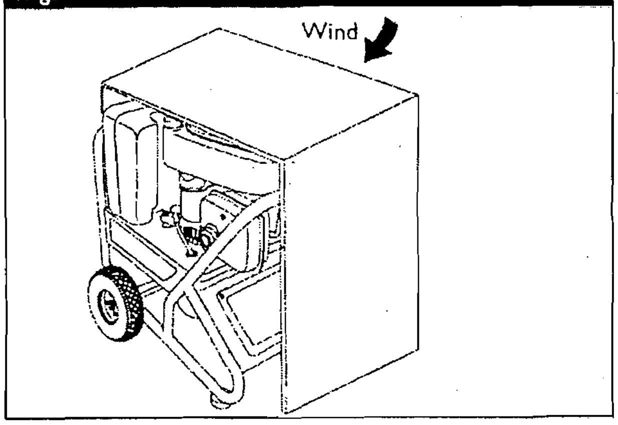
Under certain weather conditions (temperatures below 40°F [4°C] combined with high humidity), your generator may experience icing of the carburetor and/or the crankcase breather system. To reduce this problem, you need to perform the following:

1. Make sure generator has clean, fresh fuel.
2. Open fuel valve (turn valve to open position).
3. Use SAE 5W-30 oil (synthetic preferred, see engine manual).
4. Check oil level daily or after every eight (8) hours of operation.
5. Maintain generator following "Maintenance Schedule" in engine manual.
6. Shelter unit from elements.

In an emergency, use the original shipping carton as a temporary shelter:

7. Cut off all carton flaps.
8. Cut out one long side of carton to expose muffler side of unit as shown in Figure 10.

**Figure 10 — Permanent Cold Weather Shelter**




**IMPORTANT:** The generator must be at least 5 ft. (152 cm) from structures having combustible walls and/or other combustible materials. Leave at least 3 ft. (92 cm) all around generator including overhead, for adequate cooling, maintenance and servicing.

**⚠ WARNING**

**Running engines produce heat. Temperature of muffler and nearby areas can reach or exceed 150°F (65°C).**
**Severe burns can occur on contact.**
**Combustible debris, such as leaves, grass, brush, ect. can catch fire.**

- DO NOT touch hot surfaces.
- Allow equipment to cool before touching.
- The generator must be at least 5 feet from structures having combustible walls and/or other combustible materials.
- Keep at least 3 feet of clearance on all sides of generator for adequate cooling, maintenance and servicing.
- Remove shelter when temperatures are above 40°F [4°C].

9. Cut appropriate slots to access receptacles of unit.
10. Start unit, then place carton over it.

**NOTE:** Remove shelter when temperatures are above 40°F [4°C].

For a more permanent shelter, build a structure that will enclose three sides and the top of the generator.

7. Make sure entire muffler-side of generator is exposed, as shown in Figure 10.

**IMPORTANT:** The generator must be at least 5 ft. (152 cm) from structures having combustible walls and/or other combustible materials. Leave at least 3 ft. (92 cm) all around generator including overhead, for adequate cooling, maintenance and servicing.

8. Face exposed end away from wind and elements.
9. Structure should hold enough heat created by the generator to prevent icing problem.
10. Start and run engine outdoors.
11. Keep exhaust gas from entering a confined area through windows, doors, ventilation intakes or other openings.

**⚠ WARNING**

**Running generator gives off carbon monoxide, an odorless, colorless, poison gas.**
**Breathing carbon monoxide will cause nausea, fainting or death.**

- Operate generator ONLY outdoors.
- Keep exhaust gas from entering a confined area through windows, doors, ventilation intakes or other openings.
- DO NOT operate generator inside any building or enclosure, including the generator compartment of a recreational vehicle (RV).

12. DO NOT enclose generator any more than shown in Figure 10.
13. Remove shelter when temperatures are above 40°F [4°C].
14. Turn engine OFF and let cool two (2) minutes before refueling.

# TAB L

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

**Memorandum**

Date: March 31, 2006

| | | |
|---|---|---|
| TO | : | Janet Buyer, Mechanical Engineer<br>Directorate for Engineering Sciences<br>Division of Combustion and Fire Sciences |
| THROUGH: | | Andrew G. Stadnik, P.E., Associate Executive Directors<br>Directorate for Laboratory Sciences |
| FROM | : | Christopher J. Brown, Mechanical Engineer<br>Directorate for Laboratory Sciences<br>Division of Mechanical Engineering |
| SUBJECT | : | Engine Driven Tools Project: Summary of the Carbon Monoxide (CO) Generation Rates Produced By Four Engine-Driven Generators |

## Background

As part of the Engine-Driven Tools Project, U.S Consumer Product Safety Commission staff (CPSC) tested four consumer grade, gasoline-fueled, engine driven, electric power generators to determine the amount of CO produced by each generator.* The generators were operated in an environmental test chamber in which the air exchange rate and temperature were controlled, and the CO concentration inside the test chamber was continually measured. The CO generation rates were then calculated from the steady state CO concentrations and the air exchange rates.

The four generators selected for testing were readily available to consumers at retail stores. Generator A and Generator B were equipped with a 10 hp engine and had a stated continuous power rating of 5.5 kW. Generator C was equipped with a 3.5 hp engine and had a stated continuous power rating of 1.5 kW. Generator D was equipped with a 1.8 hp engine and had a stated continuous power rating of 0.9 kW.

The environmental test chamber has a volume of approximately 9.6 $m^3$ (340 $ft^3$). The air exchange rate for the test chamber was varied from 13 to 29 air exchanges per hour (ACH). The air temperature inside the chamber was varied from 10°C to 34°C (50°F to 93°F). It should be noted that the generators were tested under similar temperature and air exchange rates, but were not necessarily tested to exactly the same conditions. For most tests, the generators were

* This memorandum was prepared by the CPSC staff, has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

operated at a no-load condition at the beginning of a test, followed by either a partial-load or a full-load condition. In order to distinguish between the break-in period and post break-in period, the accumulated run time of the generator was also documented.

**Summary of the Test Results**

CPSC staff conducted a total of 115 tests on the four generators. Of the four test variables considered (generator load, room air exchange rate, room temperature, and generator accumulated run time), the generator load appeared to have the greatest affect on the rate at which the generators produced CO. In addition, the generators all produced a significant amount of CO, even though the test chamber had a normal or slightly reduced level of oxygen (it ranged between 18.6% to 21% $O_2$ for all the tests).

Table 1 provides a summary of CO generation rates for all of the tests. The table shows the difference between no-load and partial/full-load conditions. The CO generation rates were calculated using steady state values of the CO concentrations. The data presented in this memo are a summary of the data presented in the draft report titled, "Engine Driven Tools Project: Phase 1 Test Report".

**Table 1. Summary of the CO Generation Rates for the Four Generators Tested.**

| Generator | CO Generation Rate (cc/hr) | | | |
|---|---|---|---|---|
| | No Load | | Partial/Full Load | |
| | Minimum | Maximum | Minimum | Maximum |
| A | 550,000 | 780,000 | 910,000 | 1,300,000 |
| B | 330,000 | 620,000 | 540,000 | >2,100,000* |
| C | 220,000 | 380,000 | 330,000 | 810,000 |
| D | 100,000 | 190,000 | 130,000 | 480,000 |

* The actual CO generation rate is greater than the value shown. During the test, the CO concentration in the test chamber exceeded the upper range of the CO gas analysis equipment.

# TAB M

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

**Memorandum**

**Date:** November 04, 2005

**TO:** Janet Buyer, Project Manager, Portable Generators
Division of Combustion and Fire Sciences, Directorate for Engineering Sciences

**Through:** Mary Ann Danello, Ph.D., Associate Executive Director,
Directorate for Health Sciences (HS)
Lori E. Saltzman, M.S., Division Director, HS

**FROM:** Sandra E. Inkster, Ph.D., Pharmacologist, HS

**SUBJECT:** Initial staff response to Chairman Stratton's directive to review several aspects of portable generator safety, specifically the development of portable generator performance requirements that would substantially reduce carbon monoxide emissions.

**Outline**

This memorandum is intended to provide relevant information responding to point three of Chairman Stratton's memorandum of October 12, 2005 (Stratton, 2005), directing staff to review the safety of portable generators (H. Stratton, 2005). Specifically, point three calls for staff to address "*Development of portable generator performance requirements that would substantially reduce carbon monoxide emissions*".

**Background**

Currently, there is no voluntary or mandatory standard for portable generators that has safety-based performance requirements to limit the amount of carbon monoxide (CO) produced. Recent CPSC data shows a progressive increase, since 1999, in the number of reported fatal residential CO poisonings associated with consumer use of generators. As of June 27, 2005, the increase from 6 deaths in 1999, to at least 51 deaths in 2003 represents a minimum 8.5-fold increase in reported fatalities over 5 years. At this time, 35 deaths were reported for 2004, and data collection is still ongoing for this year (see Table 3, Marcy and Ascone, 2005).

Unlike combustion appliances intended for indoor operation (e.g., furnaces, water heaters, ranges, space heaters, etc.), currently marketed portable generators are intended for outdoor use; they operate at much lower combustion efficiencies and rapidly produce large amounts of CO during normal operation. The bulk of the deaths in CPSC's databases involve incidents where the product was used in an enclosed or partially-enclosed space; however, there are deaths that occurred when the products were used outdoors. CPSC incident data indicates that generators often keep running until the fuel supply is exhausted.

**Staff Assessment and Recommendations**

Staff believes that limiting the total amount of CO generated by these products is the most reliable way to limit consumer exposure to harmful CO levels. Staff believes that a generator performance requirement should be pursued to protect consumers against the hazard of acute[1] residential CO exposures that can result in death or in serious and/or lasting adverse health effects in exposed individuals. "Residential CO exposures" is explicitly specified because the majority of fatal generator-related incidents reported to CPSC, in which the location was known, identify residential settings.

A performance requirement to protect against CO poisoning from portable generators needs to be technology blind, in order to allow manufacturers the option of multiple approaches to limit hazardous CO exposures. There are a number of possible approaches to reducing consumer exposure to CO produced by generators. These include, but likely are not limited to, limiting the CO emission rate during normal operation, and/or using sensors to detect hazardous CO levels (directly or indirectly) and to initiate signals to automatically shut off the generator engine and warn consumers of the developing hazard.

Staff believes that in order to be completely technology blind, any performance requirement must be based on the likely CO hazard that would occur in a "realistic" home model under conditions that are representative of consumer usage patterns seen in the incident data. Parameters that influence CO accumulation in, and dissipation from, residential settings must be considered in order to define a "realistic" home model and "foreseeable" conditions. These parameters include:

- Location of the generator (either within the home living space/basement/crawlspace/attached garage or positioned outdoors but with the exhaust fumes able to enter nearby openings to the home (doors, windows, air intake vents, AC unit, etc.)
- Duration of operation of the generator (expected run times for a moderate-to-fully loaded generator assuming a full tank of gas)
- Overall size of the residence (for a given generation rate, the CO level will rise faster in smaller homes, therefore to offer a wide level of protection staff considers modeling should consider a reasonably conservative home size (between the 10$^{th}$ to 25$^{th}$ percentile)
- Design of the home (detached or attached, single or multiple levels, number of rooms, presence/absence of HVAC system ducting, etc.)
- Air flows between the outdoor environment and the residence and within the residence itself (the residence could be viewed as single zone with one air exchange rate, or as a multi-zone collection of different sized compartments (rooms) with differing air exchange rates between each zone and with the outdoor air; seasonal and regional variation should also be considered)

[1] As used here, acute is considered to be a single catastrophic event developing in less than 6-7 hours, i.e., the maximum time a generator can operate on a full tank of gas. This is in contrast to some scenarios seen with residential combustion appliances where longer duration CO elevations can develop over several days to weeks of continuous or periodic use, before progressing to catastrophic exposures.

In order to define the maximum acceptable levels, any standard must consider the human characteristics and factors that influence the severity of the CO poisoning hazard. These include:

- Expected exposed population (for generators, this is assumed to be the general public rather than a specific age/sex subgroup)
- Each exposed individual's location relative to the location of the generator (CPSC incident data shows incidents can involve multiple victims in different locations within a home)
- The time spent in the CO environment
- Each exposed individual's inhalation rate (related to CO uptake rate) which is significantly impacted by their activity level during the early stages of exposure (according to recent research occupants typically spend the majority of time within homes in low to moderate level activity – assuming a moderate to high level activity would provide a conservative level of protection)
- Each exposed individual's general health status

Staff believes that, in examining performance requirements for portable generators, it is appropriate to set residential CO exposure limits for generators based on nationally recognized limits to protect against death or in serious and/or lasting adverse health effects in exposed individuals. The residential CO alarm activation test points, established in the voluntary standards for CO alarms (American National Standards/Underwriters Laboratories, Inc., (ANSI/UL) 2034, International Approval Services (IAS) 6-96, or Canadian Standards Association (CSA) 6.19.01), provide a basis for a technology-blind performance requirement.

According to the scope of UL 2034, Section 1.1 "*Carbon monoxide alarms are intended to alarm at carbon monoxide levels below those that could cause a loss of ability to react to the dangers of carbon monoxide exposure.*" The CO alarm test criteria are expressed in terms of CO concentration in parts per million (ppm) x exposure duration (minutes). The test points are based on the premise of limiting the carboxyhemoglobin level (COHb)[2] in exposed healthy adults to less than 10% COHb (assuming the exposed individuals are engaged in relatively high level of activity, equivalent to a breathing rate of 30 liters/minute). In acute exposure scenarios, the average healthy adult is unlikely to perceive or be seriously impacted by health effects of CO until COHb levels rise above the 10% level. The assumption of a high activity level provides a conservative level of protection since at the alarm test points (CO ppm x minutes), less active individuals will have inhaled less CO and accumulated significantly less than 10% COHb. To illustrate, the current specific test points at which CO alarm activation is required are shown below.

[2] COHb is formed in the bloodstream when inhaled CO displaces oxygen from the blood protein hemoglobin – during early stages of CO exposure, it provides a rough measure of CO poisoning severity.

| Carbon monoxide concentration versus time for alarm test points based on 10 % COHb * | |
|---|---|
| Carbon monoxide concentration and response time | |
| Concentration, ppm | Response time, minutes |
| 70 ± 5 | 60-240 |
| 150 ± 5 | 10-50 |
| 400 ± 10 | 4-15 |

*From Section 38, UL 2034, Second Edition, 10/29/96, including subsequent revisions up to 06/28/02 assuming a highly active individual

Staff emphasizes that the actual CO levels in a performance standard to protect against CO poisoning from generators may vary significantly from those currently used for CO alarms. Developing performance requirements involves a delicate balance between the level of protection afforded and the technical as well as the economic feasibility. Staff also emphasizes that, in addition to defining performance requirements, developing a performance standard for generators will require significant testing to validate the reliability of the test methodology in the field.

**Refererences**

Stratton. H. (2005) Review of Portable Generator Safety, CPSC Chairman's memorandum to staff (October 12, 2005)

Marcy NE, Ascone DS, (2005) Incidents, Deaths, and In-Depth Investigations Associated with Carbon Monoxide and Engine-Driven Tools, 1990-2004, CPSC Epidemiology Staff memorandum.

Underwriters Laboratories (UL) voluntary standard for CO alarms (UL 2034, *Single and Multiple Station Carbon Monoxide Alarms*), Second Edition, 10/29/96, including subsequent revisions up to 06/28/02.

# TAB N

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

**Memorandum**

Date: March 31, 2006

TO : Jacqueline Elder, Assistant Executive Director
Office of Hazard Identification and Reduction

THROUGH : Hugh McLaurin, Associate Executive Director
Directorate for Engineering Sciences

Margaret Neily, Division Director
Division of Combustion and Fire Sciences

FROM : Janet Buyer, Project Manager
Division of Combustion and Fire Sciences
Directorate for Engineering Sciences

SUBJECT : Comparison of the Carbon Monoxide Emission Rate of a 5.5 kilowatt Generator with Ten Horsepower Engine to Emission Rates of Idling Cars

REF : (a) Brown, Christopher, *Engine-Driven Tools Project: Summary of the Carbon Monoxide (CO) Generation Rates Produced by Four Engine-Driven Generators*, CPSC Memorandum to Janet Buyer, U.S. Consumer Product Safety Commission, Washington, D.C., March 31, 2006.
(b) Frey, H., et al., *On-Road Measurement of Vehicle Tailpipe Emissions Using a Portable Instrument*, Journal of the Air & Waste Management Association, Vol.53, August 2003.

The purpose of this memorandum is to make a comparison of the carbon monoxide (CO) emission rate of one of the 5.5 kilowatt (kW) generators that CPSC staff tested during the Phase 1 generator test program, documented in ref (a), with those of two different cars while idling. Ref (b) provides vehicle tailpipe emissions of various cars tested on-road with a portable onboard tailpipe emissions analyzer.*

Per ref (a), LS staff calculated the steady state CO generation rate of a 5.5 kW portable generator powered by a 10 horsepower (HP) engine to be as high as 2,100,000 cubic centimeters per hour (cc/hr) while sustaining a 4.4 kW load.

Per ref (b), the range of CO emission rates measured on nine different idling gasoline-fueled cars is reported to be 0.66 milligrams per sec (mg/sec) (for an Oldsmobile Cutlass) to 1.5 mg/sec (for a Ford Taurus).

* This analysis was prepared by the CPSC staff. It has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

To convert the CO emission rate of the 5.5 kW generator from cc/hr to grams/hour, one must multiply the emission rate by the density of CO, which is 0.00115 grams/cc. Therefore, the 2,100,000 cc/hr CO from the generator equates to 2405 grams/hour.

To convert the CO emission rate of the Oldsmobile Cutlass from mg/sec to grams/hour, one must multiply the emission rate by 3600 sec/hr and then multiply by 1 gram/1000 mg. Therefore the 0.66 mg/sec CO from the Oldmobile Cutlass equates to 2.37 grams/hour.

The ratio of the generator CO emission rate to that of the idling Oldsmobile Cutlass is **1,012**.

Performing similar calculations for the Ford Taurus, the ratio of the generator CO emission rate to that of the idling Ford Taurus is **445**.

Based on these calculations, staff estimates that a typical 5.5 kW generator can produce CO at rates nominally between 450 to 1,000 times that of various idling cars.

# TAB O

# Westerbeke "Safe-CO™" Generators Slash Carbon Monoxide Emissions By More Than 99% To Greatly Improve Boating Safety.

Taunton, MA (USA), 12 February 2004 ---- Westerbeke Corporation, one of the world's leading producers of gasoline-and diesel-powered generators for the marine market, has unveiled a new series of gasoline-fueled generators which, for the first time, reduce carbon monoxide (CO) emissions to a safe level. Compared with typical carbureted AND conventional EFI (electronically fuel-injected) generators, Westerbeke's "Safe-COTM" generators eliminate more than 99% of those life-threatening gases.

Westerbeke exhibited the first of their Safe-COTM Series at the 2004 Miami International Boat Show in February. Westerbeke's Safe-COTM Series, which uses a combination of innovative engineering (patents pending) and electronic fuel injection to achieve these safety-enhancing and environmentally friendly low emissions, has nine Safe-COTM models, based on 2, 3 and 4-cylinder engines.

Carbon monoxide poisoning of recreational boaters is a serious and growing problem, especially with the trend for boats of all types to add equipment which requires onboard generation of electricity. The danger from this colorless, odorless, and extremely poisonous gas, often called "the silent killer", has historically not been widely discussed in boating circles, and some news reports have erroneously indicated that the danger is only in freshwater houseboating. But lately, the scope of the danger has been demonstrated among powerboats in general and on saltwater as well.





WESTERBEKE CORPORATION
MYLES STANDISH INDUSTRIAL PARK, 150 JOHN HANCOCK ROAD, TAUNTON, MA 02780-7319 • TEL. 508-823-7677 • FAX 508-884-9688 • WEBSITE: WWW.WESTERBEKE.COM

Government on-water testing, prompted by an increase in recorded fatalities, has measured the high degree of risk present in emissions from gasoline-fueled generators and engines. This research has focused on both in-cabin and outside-the-cabin exposures, the latter of which have proven to be just as dangerous with 160 poisonings, 71% of which produced fatalities (48) or lost-consciousness (65). In one test (Lake Havasu over Memorial Day, 2003) shoreside and on-water CO-levels were so dangerous that park wardens had to be removed for their personal safety - an event that was even recorded in Time Magazine!

While there is controversy between health organizations and industry groups over setting limits on CO-exposure, Westerbeke clearly saw that CO exposure had become both a serious health issue for boaters and an environmental concern. So the Company decided that its new generators would meet the strictest of standards. To do this, Westerbeke developed its new Safe-COTM Series of generators with a target of 99% or better reduction in CO emissions. And all of Westerbeke's Safe-COTM generators meet that target as well as comply with many of the most stringent restrictions proposed by environmental groups and government agencies.

Several governmental organizations have researched CO emissions and have set the standards used outside of boating. For example, the National Institute for Occupational Safety & Health (NIOSH) has set 35 parts per million (ppm) as the Recommended Exposure Limit (REL) for shift time-weighted average (TWA) exposure, with a ceiling limit of 200 ppm (which should never be exceeded). Further, they determined that 1200 ppm is immediately hazardous to life and health. The American Conference of Government Industrial Hygienists (ACGIH) set their 8-hour TWA at 25 ppm, and discourages exposure (30-minute maximum) above 125 ppm. OSHA has established a maximum 8-hour permissible exposure at 50 ppm.

Even tougher standards exist: The U.S. EPA has set a National Ambient Air Quality Standard (NAAQS) of 9 ppm for 8-hour TWA and 35 ppm for 1-hour exposure. And the World Health Organization (WHO) has recommended a 1-hour limit of 26 ppm (87 ppm for 15-minute exposure).

Westerbeke feels that recreational boating should be made especially safe and has taken the position that the boating public should insist on the lowest obtainable CO emissions limits. Westerbeke Safe-COTM Series generators demonstrate that boating can be made safer: carbon monoxide poisoning need not be a boating statistic from now on.

For more information on "Safe-COTM" generators, contact Westerbeke Corporation, 150 John Hancock Road, Taunton, Massachusetts 02780 USA. Telephone: 508.823.7677 Fax: 508.884.9688 Email: help@westerbeke.com Website: www.westerbeke.com

Westerbeke Safe-COTM Series Generators - Partial Specifications

| Model | RPM (60 Hz) | Cylinders | Capacity CID | Capacity Ltrs. | L (in inches) | W (in inches) | H (in inches) | Weight (pounds) |
|---|---|---|---|---|---|---|---|---|
| 3.0 SBPMG | 2200 | 2 | 20 | 0.3 | 24.6 | 13.6 | 14.5 | 165 |
| 5.0 SBCG | 1800 | 3 | 40 | 0.7 | 25.2 | 15.4 | 16.9 | 307 |
| 7.0 SBCGC | 1800 | 3 | 40 | 0.7 | 16.2 | 15.2 | 16.9 | 338 |
| 8.0 SBEG | 1800 | 4 | 90 | 1.5 | 32.6 | 20.8 | 23.5 | 440 |
| 10.0 SBEG | 1800 | 4 | 90 | 1.5 | 33.8 | 20.8 | 23.5 | 466 |
| 12.5 SBEG | 1800 | 4 | 90 | 1.5 | 34.8 | 20.8 | 23.5 | 497 |
| 15.0 SBEG | 1800 | 4 | 90 | 1.5 | 36.1 | 20.8 | 23.5 | 525 |
| 20.0 SBEG | 1800 | 4 | 133 | 2.2 | 42.0 | 22.4 | 28.2 | 940 |
| 25.0 SBEG | 1800 | 4 | 133 | 2.2 | 42.0 | 22.4 | 28.2 | 968 |

Above data is provided for information purposes only and is subject to change without notice; consult Westerbeke for latest specifications.

* * * * RELEASE TEXT ENDS * * * *

# PRESS ROOM



August 2005

**New Generation Gasoline Generators From Kohler Reduce Carbon Monoxide Emissions By 99 Percent**

KOHLER, Wis. – August 2005 – Kohler Power Systems, the market leader in gasoline-powered marine generators, introduces a new line of marine generators that nearly eliminate carbon monoxide (CO) emissions altogether.

The new low carbon monoxide KOHLER gasoline generators significantly reduce CO emissions by 99 percent, which both EPA emissions and Kohler reliability tests confirm. The new KOHLER gasoline generators exceed both CARB and EPA standards for CO and HC+ NOx emission levels, and have received certification from both organizations.

The Kohler 5ECD and 7.3ECD models are available for immediate delivery, while the 10-15kW models will be available in first quarter 2006. Several pleasure-craft brands will feature the new KOHLER low carbon monoxide generators on 2006 models.
"We've replaced the carburetor with an adaptive strategy, computer-controlled engine utilizing electronic fuel injection that is responsive and reduces the carbon monoxide emitted from gasoline-powered generators," said Richard Koehl, Director of Engineering-Kohler Power Systems.
"What's also significant about this new line of low carbon monoxide generators is that we've been able to engineer it so that it is simple to access and service if necessary," said Koehl, recognizing that the one-side serviceability of the fuel filter, cooling system and lubrication system is attractive to boat owners. The new bulkhead installation panel also makes installation easier due to external connections to the generator. The new KOHLER low carbon monoxide generators also feature significantly fewer parts than competitive models.

Maintaining a safe temperature using the generator catalyst technology is another innovation Kohler has been able to offer. "We've engineered a way to utilize water to cool the generator catalyst, which will keep all the under-the-deck generator components cool and therefore, safe to the touch." Kohler has filed a provisional patent application on the cool catalyst technology, said Koehl.

Kohler Power Systems has also introduced an engine control module to its new line of gasoline generators, which is unique to the market, said Koehl. The module and the patented Kohler Advanced Digital Control work in harmony to optimize all generator and engine functions and to adapt the engine to the requirements of use during its lifetime.

**Generator features**

- Four-cycle, two-cylinder gasoline engine (3600 RPM at 60Hz) with an electronic governor. The engine meets U.S. Coast Guard safety standards for electrical systems and gasoline-fuel systems (33CFR183).
- The sequential port, throttle body, fuel-injected system offers a fuel savings of up to 25% over current KOHLER gasoline generator models.
- Kohler offers the first and only integrated fuel pump cooler, which requires no fuel return line to the fuel tank.
- The 5 and 7.3ECD generators are compact and lightweight. Both the 5kW and 7.3kW KOHLER generators are 17.45"W x 28.45"L x 17.25"H and weigh only 200 lbs.
- Sound-shielded generator set installations are simplified with the use of the bulkhead connection panel.
- Kohler gasoline generators remain one of the quietest in the market. Optional aluminum sound shields reduce the generator sound to 68 d(B)A at 1 meter.

**Advanced Digital Control**

Never before has Kohler Power Systems offered a more advanced microprocessor controller on its range of marine generators. The KOHLER Advanced Digital Control (ADC) has been a standard feature on its recently released diesel generators (8-32kW) and is now available on its newest gasoline generators. Monitoring 13 fault conditions, the ADC was designed to deliver more precise voltage and frequency regulation for today's sophisticated boating electronics. The ADC offers enhanced diagnostic and critical generator operational parameters on an easy-to-read seven-segment alphanumeric display. The ADC displays runtime hours, cyclic crank status, and system fault codes. The 5 and 7.3ECD features SmartCraft™ output capabilities.

**Remote Digital Gauge**

Complete systems monitoring includes the optional three-inch Remote Digital Gauge which is available on all models. The remote digital gauge provides starting/stopping and complete systems monitoring from a location outside of the engine room (i.e., at the yacht's helm or distribution panel).

Kohler Power Systems is a division of Kohler Co., and provides complete power systems, including generators (stationary, residential, mobile and marine), automatic transfer switches, switchgear, monitoring controls, and accessories for emergency, prime power, and energy-management applications. Kohler Power Systems delivers energy solutions for markets worldwide. Frost & Sullivan, a global growth consulting company, named Kohler Power Systems the 2003 Energy Industry Company of the Year.

Founded in 1873 and headquartered in Kohler, Wis., Kohler Co. is one of the nation's oldest and largest privately held companies. Kohler is a worldwide leader in the manufacture of kitchen and bath products, utility engines and power-generation systems, home interiors, and hospitality services.

SmartCraft™ is a trademark of Mercury Marine, a division of Brunswick Corp.

# TAB P

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

**Memorandum**

**Date:** September 7, 2006

**TO:** Janet Buyer, Project Manager, Portable Generators
Division of Combustion and Fire Sciences, Directorate for Engineering Sciences

**Through:** Mary Ann Danello, Ph.D., Associate Executive Director,
Directorate for Health Sciences (HS)
Lori E. Saltzman, M.S., Division Director, HS

**FROM:** Sandra E. Inkster, Ph.D., Pharmacologist, HS

**SUBJECT:** An estimation of how reductions in the carbon monoxide (CO) emission rate of portable, gasoline-powered generators could impact the chance of surviving an acute CO exposure resulting from operation of a portable gasoline-powered generator in a basement.

**Outline**

This memorandum is intended to provide some guidance on the potential effectiveness of reductions in portable generator CO emissions in significantly improving consumer safety. Health Sciences (HS) staff employed a theoretical, mathematical, modeling approach to CO emissions rate data (derived from the CPSC Laboratory Sciences (LS) generator testing program) to estimate the impact on a consumer's chance of surviving an acute CO exposure resulting from indoor operation of a portable generator.

**Background**

The U.S. Consumer Product Safety Commission (CPSC) staff is concerned by the rising death toll from carbon monoxide (CO) poisoning caused by consumer exposure to exhaust gases of portable generators. CPSC data indicate that these cases have involved primarily, but not exclusively, generators with gasoline-powered combustion engines. On October 12, 2005, the former CPSC Chairman, Hal Stratton, issued a directive charging staff to conduct "a thorough review of the status of portable generator safety." Point 3 of this directive, specifically called for staff to address "development of portable generator performance requirements that would substantially reduce CO emissions." CPSC technical staff has reasoned that one of the most effective ways to reduce or mitigate the generator-associated CO poisoning hazard would be to reduce the amount of CO emitted by a generator's combustion engine, but has also noted that any performance requirement to reduce consumer exposure to hazardous CO levels must be "technologically blind." This means manufacturers must be free to decide on product designs incorporated in order to achieve the objective of reduced consumer exposure to generator CO emissions (HS draft memo, November 2005). CPSC Engineering Sciences (ES) staff is currently endeavoring to assess the feasibility of engineering approaches that could result in reduced generator CO emissions. However, valid questions have been raised as to how much of a reduction in a generator's CO emission rate is needed to achieve any realistic improvement in a consumer's chances of surviving a life-threatening CO exposure. Providing a definitive answer to this question is challenging given the large number and range of variables involved, but some guidance is provided in this memorandum, based on results obtained using a theoretical mathematical modeling approach, as described below.

**Introduction**

In Spring 2004, in preparation for an upcoming Public Forum on portable generators, CPSC LS staff's preliminary data on CO emission rates from a 5.5 kilowatt, portable gasoline-powered generator (hereon referred to as "generator") were modeled to assess how CO, emitted by a generator being operated in a basement, would spread through the living areas of a representative home. The operational status of a home's HVAC fan has a powerful impact on indoor air distribution, therefore, LS staff modeled scenarios assuming the HVAC fan was operating and was not operating. The resulting CO time-course data was then modeled by HS staff to (a) determine the likely accumulation of carboxyhemoglobin[1] (COHb) in consumers positioned at different locations within the home, and (b) assess the consequent health effects expected from the CO exposure. Sedentary and moderate activity levels were modeled by applying respiratory minute volumes (RMVs)[2] of 6 L/min and 20 L/min, respectively, for each CO scenario profile subjected to COHb modeling. Details of LS and HS modeling assumptions used, the CO emission rates modeled, and CO and COHb time course profiles are provided in the earlier HS staff memorandum (Inkster, 2004).

In short, the health assessment of preliminary CO emission rates found that a generator operated at full load (considered by staff as the most likely consumer-use scenario) within a basement, would be expected to result in lethal CO exposures in all living areas of the home, regardless of the HVAC fan's operational status. In all cases, lethal CO exposures developed rapidly in the basement, then subsequently spread to the rest of the home over several hours from generator start-up. With the HVAC fan running, nearly identical profiles were found in all non-basement home areas both for CO and for % COHb. With the HVAC fan off, there was a staggered progression of lethal CO and COHb buildup from the first to second floors, with highest peak levels being attained on the lower floor. All modeled scenarios assumed a generator had operated for 6-hours at full load on a full tank of gasoline.

Since the preliminary report, subsequent work by LS staff has determined that significantly higher full-load CO emission rates can be expected from similar 5.5 kilowatt generator models, i.e., ~2,100,000 cc/h versus the maximum CO emission rate previously modeled, ~1,183,000 cc/h (see draft report, C.J. Brown, August 2006). LS staff provided HS staff with updated modeled profiles[3] of CO buildup throughout a representative home for these

[1] Carboxyhemoglobin (COHb) is the product formed in the bloodstream when inhaled CO replaces and displaces oxygen in complexing with hemoglobin, the vital oxygen-transport protein present in red blood cells. COHb levels are typically expressed as a percentage of the total amount of hemoglobin present. Although the relationship is not absolute, % COHb levels can provide a useful index of CO poisoning severity (see Inkster, 2004).

[2] The respiratory minute volume (RMV)[2] is the physiological measure of the volume of air inspired each minute (L/min); it typically increases with, and is used as an indicator of, an individual's activity level.

[3] These CO profiles were modeled by LS staff using representative input parameters as previously described (Inkster, 2004).

higher emission rates; (personal communication from C. Brown to S. Inkster, May 2006). For this memorandum, HS staff has utilized these updated CO profiles as the basis for determining how various percentage reductions in generator CO emissions could likely impact a consumer's chances of surviving a CO exposure resulting from operation of a generator within a basement.

**Data Modeling**

As requested by ES staff, HS staff (a) assessed the impact of progressive percentage reductions in the 100% CO emission rate of 2,100,000 cc/hr on expected CO buildup throughout a home (reductions of 40, 50, 65, 75, 85, and 92%, respectively), and (b) modeled the corresponding % COHb levels predicted for the reduced emission rate CO profiles.

There are relatively minor differences in air flow between living areas on the same level of the representative home model[4], therefore due to time constraints, HS staff modeled a single room or area from each level of the representative home (i.e., second level bedroom 1, ground-floor kitchen, and the basement area). As before, scenarios with the HVAC fan on and HVAC fan off were considered. A simple mathematical correction factor was applied to convert LS staff's CO profiles for the 100% emissions data set to equivalent CO levels for each selected percentage reduction in CO emissions. However, the physiological processes involved in CO uptake, absorption, and elimination from the body are complex and so preclude such a simple factor adjustment of COHb levels. Therefore, HS staff individually modeled COHb profiles from CO time-course profiles for each home area using a computer-based Coburn-Forster-Kane (CFK)[5] modeling program. HS staff notes that all physiological input parameters used in this assessment were as previously reported (Inkster, 2004) except for the input value selected for the RMV, which is used to reflect an individual's activity level. In the 2004 report, HS staff modeled both sedentary and moderate activity levels using RMV values of 6 and 20 L/min, respectively. For this report, after consultation with ES staff, HS staff used an intermediate RMV value of 15 L/min for COHb modeling to reflect an intermediate low-to-moderate activity level for occupants in each area. In addition, staff modeled COHb levels for bedroom occupants using a lower 6 L/min RMV to assess how reduced CO emissions would likely impact sleeping individuals.

**Results**

As is expected, and has been previously reported, in scenarios where the HVAC fan is not operating, the CO emissions accumulate first, and reach highest levels in the basement area. CO is progressively distributed by natural air flow within the home, first to the ground level and then to the second level areas. The second level bedroom is furthest from the basement and therefore attains the lowest peak CO levels some considerable time after peak levels are reached in the basement and on the ground floor. With the HVAC fan on, in terms of time and duration,

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[4] The home model used in the previous report (Inkster, 2004; Brown, 2006) was utilized for this report. HS staff recognizes that there is a broad range of home designs and characteristics throughout the U.S. reflecting multiple influences (e.g., chronological, regional, climactic, financial factors etc., plus consumers' personal preferences). It is not practical to model all possible home characteristics and generator use scenarios; however, technical staff is collaborating with NIST staff through an interagency agreement to model representative scenarios reported in CPSC field investigations of lethal CO poisoning generator incidents.

[5] The non-linear form of the Coburn-Forster-Kane (CFK) equation is widely regarded in the medical research community as being the most physiologically accurate, predictive model for estimating COHb levels that also has the broadest application for different CO exposure scenarios (EPA, 2000)

the CO is almost evenly distributed to the rest of the home within a relatively a short lag time after basement levels rise; also, peak levels in the basement are reduced compared to the corresponding "HVAC fan off" scenario. The predicted COHb profiles for low to moderately active occupants on each home level, corresponding to the 100% CO emission rate and 40, 50, 65, 75, 85 and 92% reduced emission rates, are illustrated graphically in Figures 1A-G (HVAC fan on) and 1A'-G' (HVAC fan off). For sleeping occupants located in the upper level bedroom, the predicted COHb profiles corresponding to the 100% CO emission rate, and 40, 50, 65, 75, 85 and 92% reduced emission rates, are illustrated graphically in Figures 2A (HVAC fan on) and 2B (HVAC fan off).

The figures show that, although the progressive reductions in CO emissions delay the time taken for COHb levels to increase (curves are shifted to the right), and to some extent decrease the peak % COHb levels and duration of attainment, even substantial reductions in CO emissions of up to 92%, cannot prevent CO levels capable of causing adverse health effects, from developing throughout a home when a generator is operated in the basement. At 92% reduced CO emissions, with the HVAC fan off (Fig 1A′), predicted COHb elevations for conscious bedroom occupants engaged in low to moderate activity, do not reach 30%, and though likely experiencing acute adverse health effects (severe headache, nausea, vomiting, etc.,) it is possible that a significant proportion of healthy individuals, could recover without lasting impact from the CO exposure. For sleeping bedroom occupants, the outlook is more favorable, since with reduced inspiration of CO at 6L/min RMV, predicted COHb levels would not reach 20%, therefore milder headache, fatigue and nausea would be expected and residual effects unlikely in non-sensitive populations. At 92% reduced emissions with the HVAC fan on, for conscious occupants, the predicted COHb levels in the first and second floor rooms would be elevated above 40% for at least 4 hours, peaking close to 50% COHb. These exposures would likely result in loss of consciousness and do pose a risk of death and delayed neurological sequelae (DNS). Somewhat lesser severity exposures would be expected for sleeping occupants of upper level bedrooms, where predicted COHb levels would be elevated above 30% for almost 5h, peaking around 36%. These exposures would likely cause severe headaches, nausea and vomiting and there is a possibility of DNS, though death would be unlikely in non-sensitive populations. For conscious occupants, there appears to be a very minimal improvement in consumer safety at reduced CO emissions up to 85%, where likely or potentially lethal COHb elevations[6] are predicted to result for those in all home areas except for the upper level bedroom in the "85% reduced CO emissions/HVAC off" scenario (Fig 1B′). Here, predicted COHb elevations rise above 40% for about 1 hour and 40 minutes, peaking at 42%, and are sustained above 30% for almost 6 hours. The health impact of this less severe COHb elevation is not uniform and subject to wide individual variation, even among healthy adults. Death is possible though unlikely, and symptoms are expected to range from serious effects such as loss of consciousness and DNS to complete recovery. For sleeping occupants of upper level bedrooms, at 85% reduced emissions with the HVAC fan off, predicted COHb levels would peak and be maintained at 30% for just over an hour. Moderate to severe headaches, nausea and vomiting would be expected and there is a possibility of DNS, though death would not be expected in non-sensitive populations

[6] COHb levels above 70% and/or prolonged elevations of several hours duration above 50-60% COHb

Table 1 provides summary details of attainment, duration and decline of selected % COHb levels for the different modeling runs represented in figures 1A-G, 1A'-G', together with summary assessments of the likely CO poisoning health effects expected for low to moderately active individuals on each level of the representative home. To facilitate interpretation, three different font colors are used to distinguish between the three generic predicted outcomes. Green font is used for the least damaging outcome of "mild to moderate poisoning -lower possibility of DNS" (delayed neurological sequelae); blue font is used for "serious poisoning: DNS probable/death possible" and red font is used for the most serious exposures where "death is likely". Table 2 provides similar summary details and color coded predicted outcomes for data in Fig 2A and 2B for occupants presumed to be sleeping in the bedroom area.

**Conclusions**

Staff recognizes that the available incident data shows that a significant number of consumers have died because they used their generators within or in close proximity to living spaces (basements, porches, garages, crawlspaces etc). When current designs of generators are operated in poorly ventilated spaces, CO can build up rapidly throughout a home to reach lethal levels. Even when a generator is operated outside, but in close enough proximity to a home to allow exhaust gases to infiltrate the living space air (near open doors, windows, air vents, etc.), serious injuries and even death has been reported.

HS staff's current modeling studies indicate that reductions of around 92% in a generator's CO emission rate, though not preventing occurrence of adverse health effects, ***can likely result in significant delay, and reduced severity, of the CO exposure in occupants located outside of the immediate area where the generator is operated.*** This means that home occupants with intact faculties, who are not sleeping, may possibly have time to recognize that their developing symptoms are indicative of a hazardous exposure before being incapacitated and prevented from taking appropriate corrective actions. Furthermore, with such a significant reduction in CO emissions, depending on the occupant's location relative to the generator, there is a greater likelihood that they might be able to survive the CO exposure without any serious residual impact on their health, even if they did not leave the environment, such as could be the case for those asleep in upper level bedrooms. Additionally, reduced emissions of around 92% would be expected to be of even more significant benefit to consumer safety in situations where generator fumes infiltrate the home from the outdoors.

It is important to recognize that even 92% reductions in CO emission rates ***are not likely to be of significant benefit to consumers who remain in other enclosed or partially enclosed locations where a generator is operated (basements, garages, sheds, etc.)*** The rapid accumulation of lethal CO levels in these areas would still be expected to result in fatal CO poisoning. This scenario is associated with a number of fatal incidents reported to CPSC.

**Some Important Considerations and Limitations of the Modeled Data**

HS staff notes that modeled indoor air CO profiles used here are intended to apply to a representative situation. Obviously, the size of a home and the rates of air exchange with the outdoor environment significantly impact the development of the potential CO hazard within the home. Using larger homes and higher air exchange rates would reduce the hazard, while smaller homes and lower air exchange rates would exacerbate the development of the CO hazard. In addition, the model only applies to situations where a 5.5 kilowatt generator is operated for approximately 6 hours at full load, on a full tank of gas. Any increase in the gas supply resulting from use of larger fuel tanks or from repeated filling of the gas tanks[7] will increase the peak CO levels, and duration of the CO elevation throughout the home. In general, under similar operating conditions, larger sized combustions engines of similar design with increased electrical output are expected to have increased CO emission rates, whereas smaller engines would be expected to have reduced CO emissions.

HS staff cautions that it should be clearly recognized that use of any model to predict COHb levels will give **approximate** estimates, the reliability of which will be dependent on how closely the input values represent the population characteristics and environmental exposure conditions. In addition, the modeling and interpretations of health impact applied here are based on healthy adults. It is recognized that certain subpopulations including those with cardiovascular disease, anemia, compromised lung function, and normal individuals such as children, and pregnant women and developing fetus, under specific circumstances are more susceptible to CO poisoning (Burton, 1996).

[7] Refueling is a less likely cause of increased running times because, unless an interval of several hours is allowed after the fuel tank runs dry, deadly CO levels would remain in the basement area. This means a person entering the area to attempt refueling would likely be overcome within a few minutes, by the extremely high level of CO that is expected to accumulate within an hour or so of the generator start-up. Also, if the person had been in other areas of the house while the generator was operating, they would be expected to have been already overcome by serious CO poisoning and be incapable of attempting refueling.

**References**

Brown C (August 2006), CPSC Laboratory Sciences draft report, Engine Driven Tools, Phase 1 test report for portable electric generators, U.S. Consumer Product Safety Commission, Washington, D.C.

Brown C (May, 2006), CPSC Laboratory Sciences, Division of Mechanical Engineering, personal communication with S. Inkster, CPSC Health Sciences.

Burton LE, (July 1, 1996) CPSC Health Sciences Memorandum, *Toxicity from Low Level Human Exposure to Carbon Monoxide*, U.S. Consumer Product Safety Commission, Washington, D.C.

Coburn RF, Forster RE, Kane PB, (1965) Considerations of the physiological variables that determine the blood carboxyhemoglobin concentration in man. J. Clinical Investigation, 44:1899-1910.

Inkster SE, (September 21, 2004) CPSC Memorandum to Janet Buyer, *Health hazard assessment of CO poisoning associated with emissions from a portable, 5.5 kilowatt, gasoline-powered generator*, U.S. Consumer Product Safety Commission, Washington, D.C.

Inkster SE, (November 4, 2005) September 21, 2004) DRAFT CPSC Memorandum to Janet Buyer, *Initial staff response to Chairman Stratton's directive to review several aspects of portable generator safety, specifically the development of portable generator performance requirements that would substantially reduce carbon monoxide emissions,* U.S. Consumer Product Safety Commission, Washington, D.C.

Stratton H, (October 12, 2005) CPSC Chairman's Directive to staff to conduct a *Review of Portable Generator Safety,* U.S. Consumer Product Safety Commission, Washington, D.C.

U.S. EPA, (2000) Air quality Criteria for Carbon Monoxide, EPA 600/P-99/001F. (website http://www.epa.gov/NCEA/pdfs/coaqcd.pdf)

Fig 1A
92%
HVAC
ON

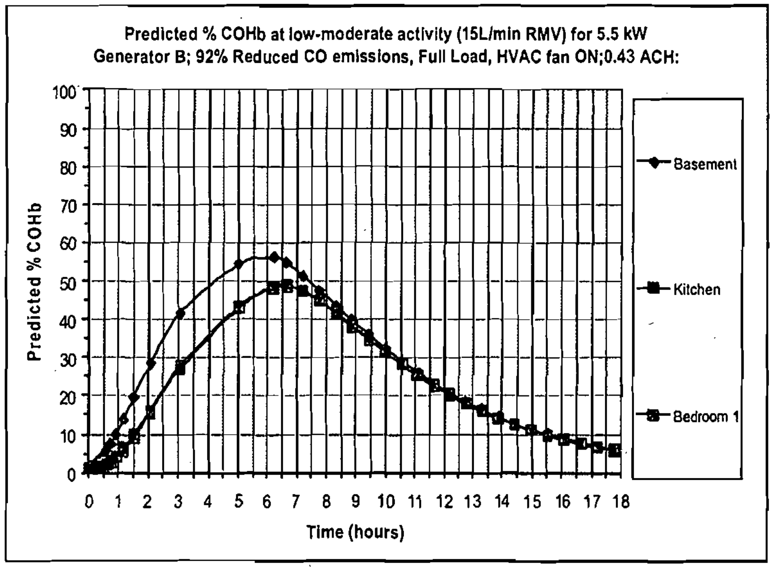



Fig 1A'
92%
HVAC
OFF

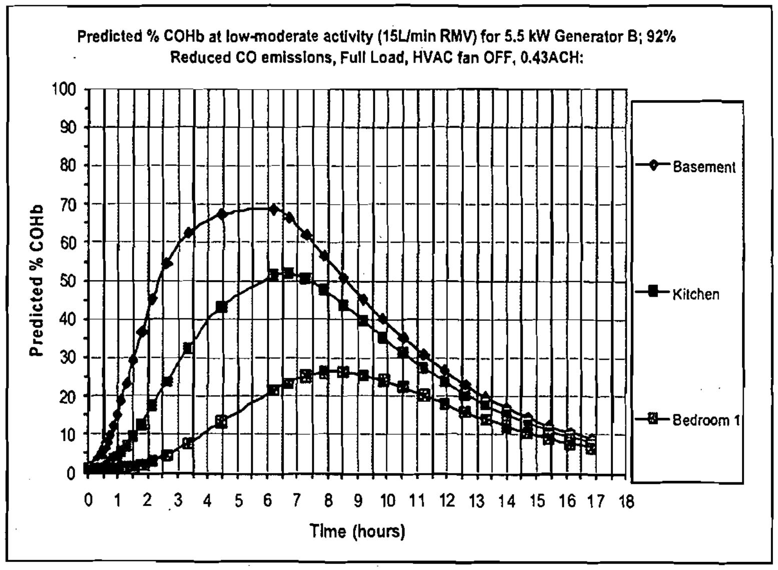



Fig 1B
85%
HVAC
ON

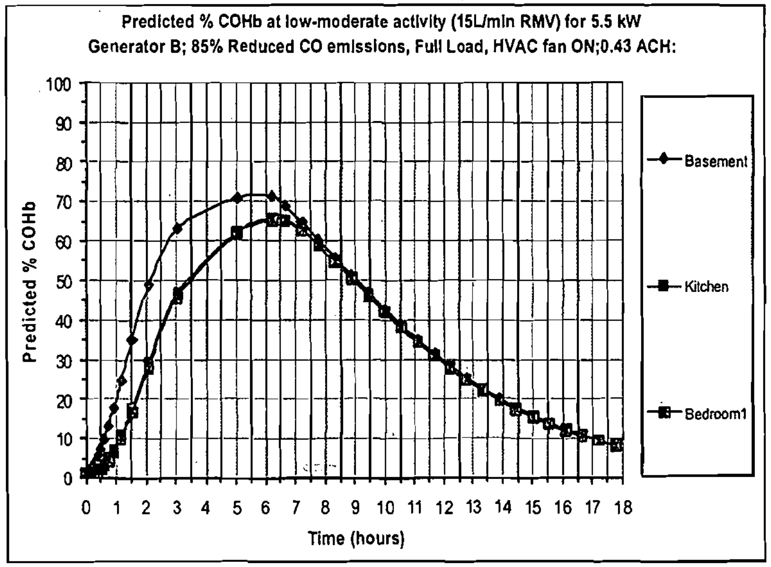



Fig 1B'
85%
HVAC
OFF

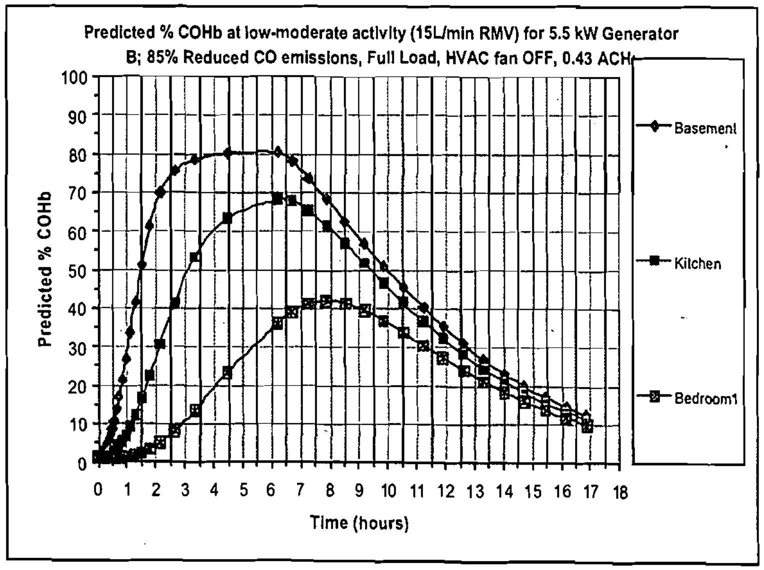


Fig 1C
75%
HVAC
ON

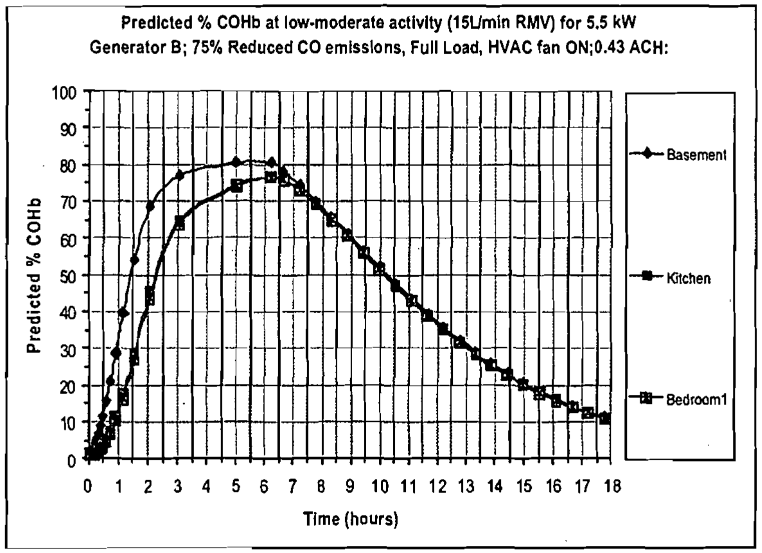



Fig 1C'
75%
HVAC
OFF

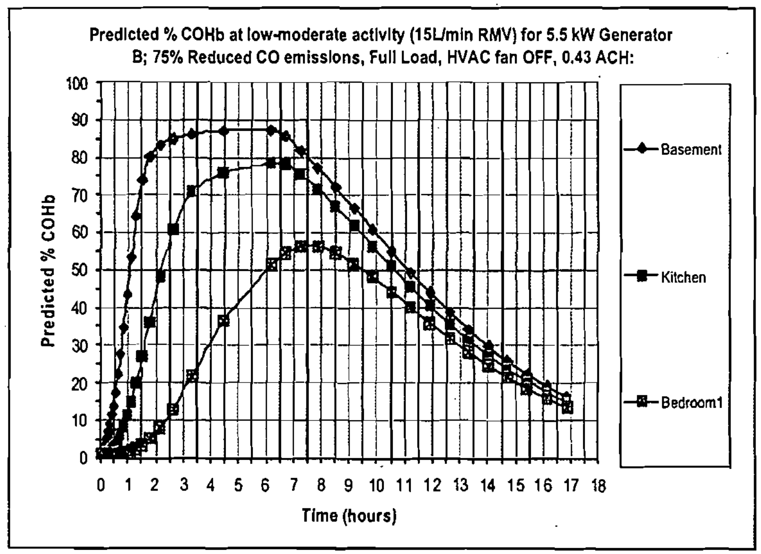



Fig 1D
65%
HVAC
ON

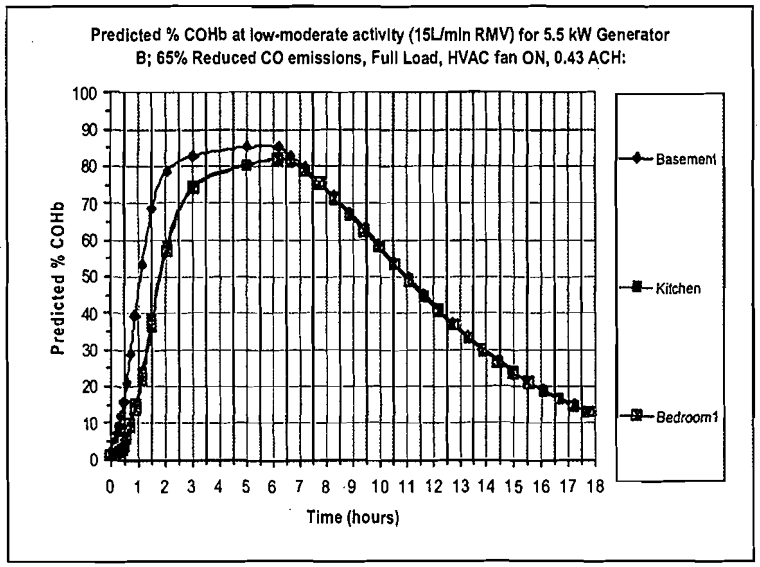



Fig 1D'
65%
HVAC
OFF

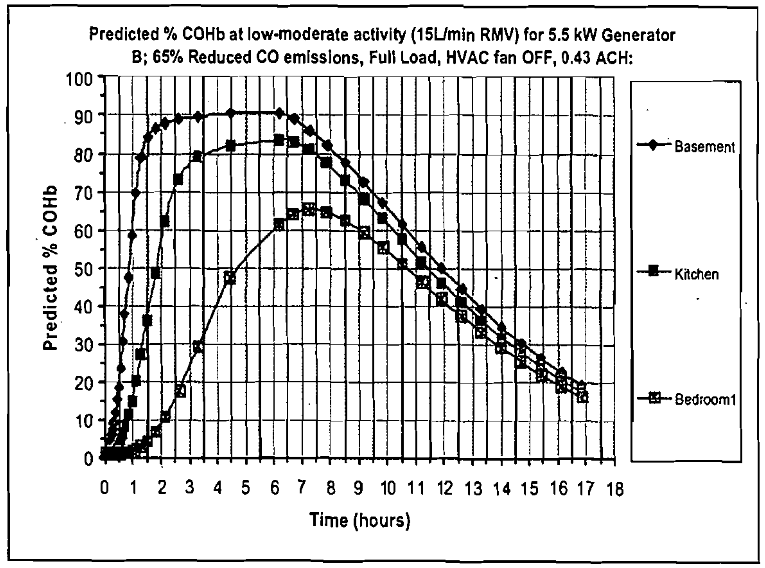


Fig 1E
50%
HVAC
ON

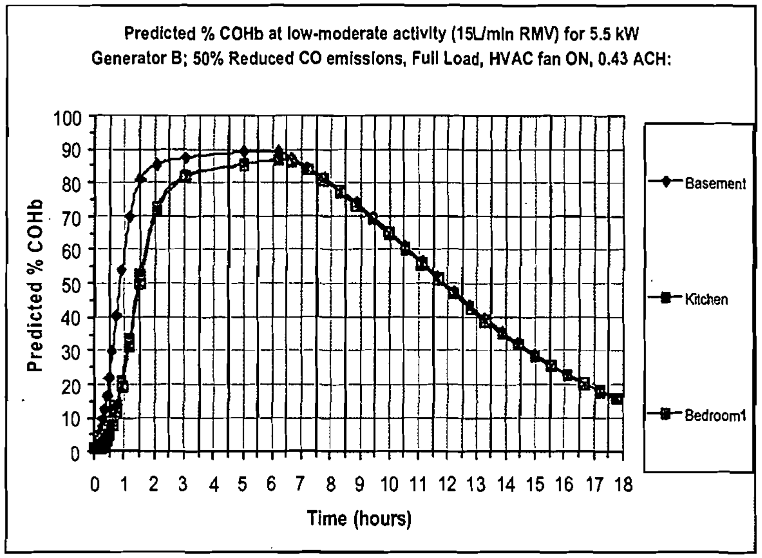



Fig 1E'
50%
HVAC
OFF

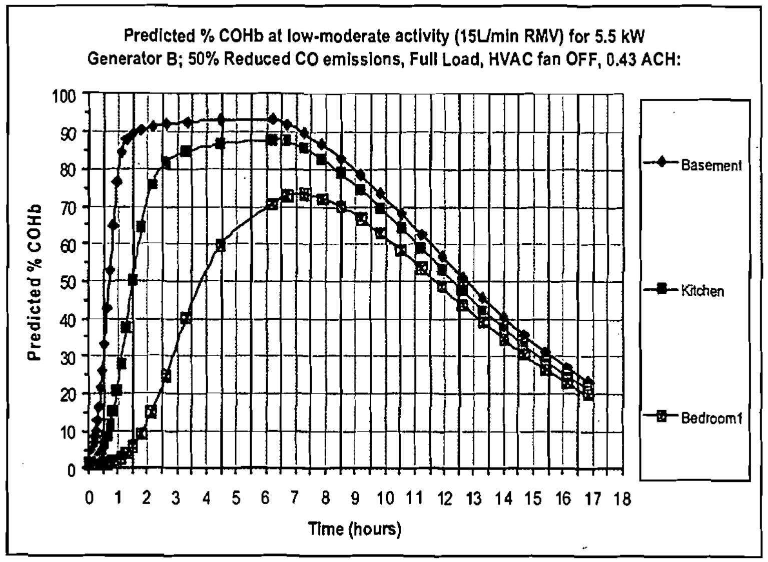



Fig 1F
40%
HVAC
ON

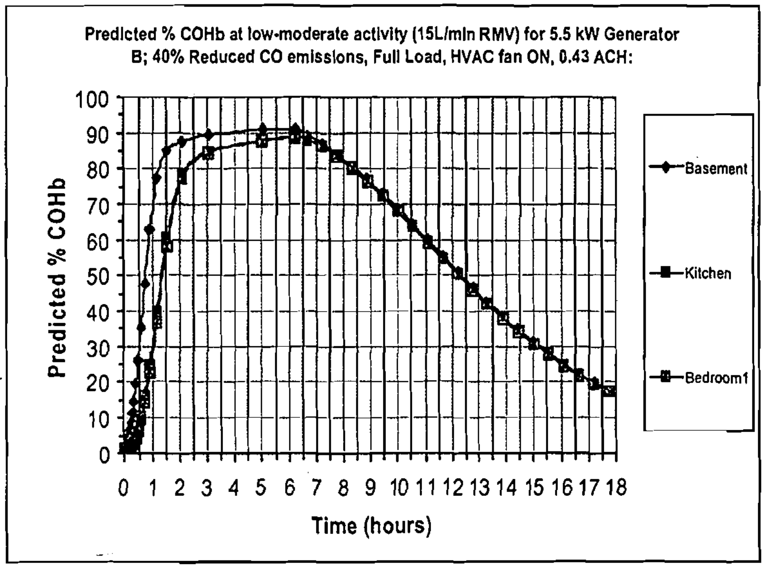



Fig 1F'
40%
HVAC
OFF

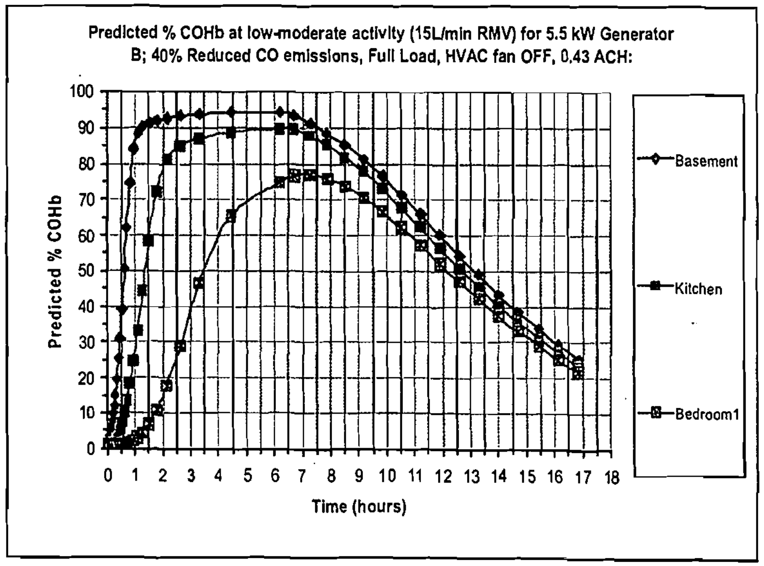


Fig 1G
0%
HVAC
ON

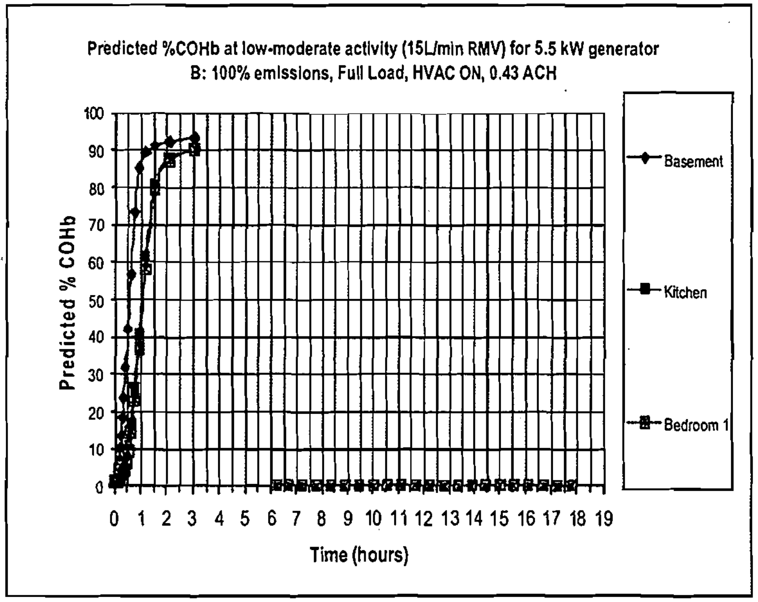
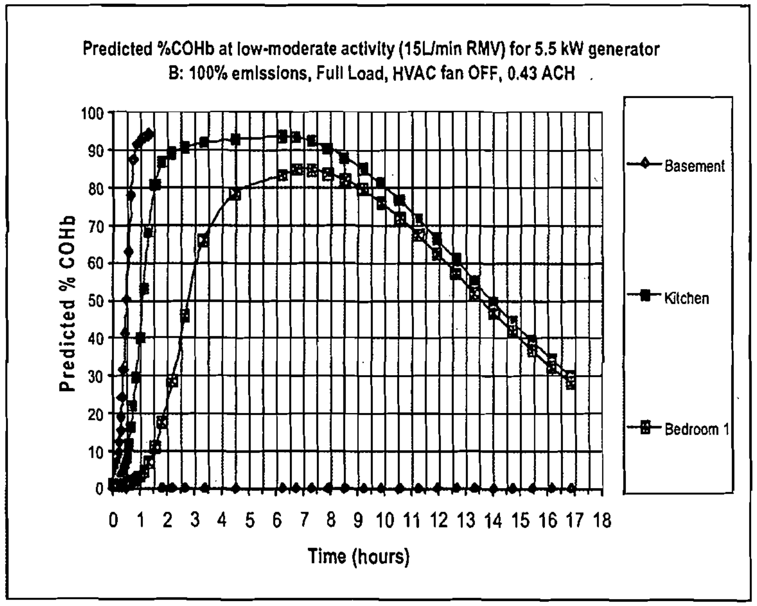



Fig 1G'
0%
HVAC
OFF



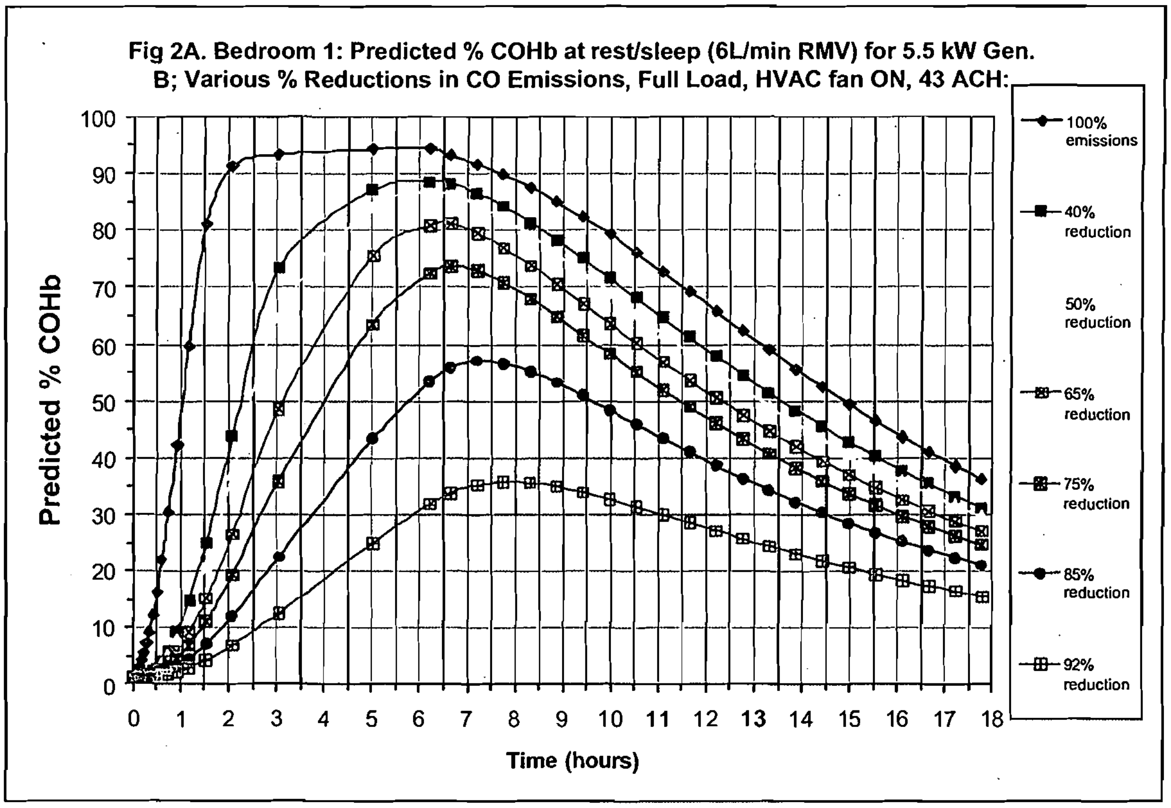


Fig 2A. Bedroom 1: Predicted % COHb at rest/sleep (6L/min RMV) for 5.5 kW Gen. B; Various % Reductions in CO Emissions, Full Load, HVAC fan ON, 43 ACH:
Predicted % COHb
Time (hours)
100% emissions
40% reduction
50% reduction
65% reduction
75% reduction
85% reduction
92% reduction

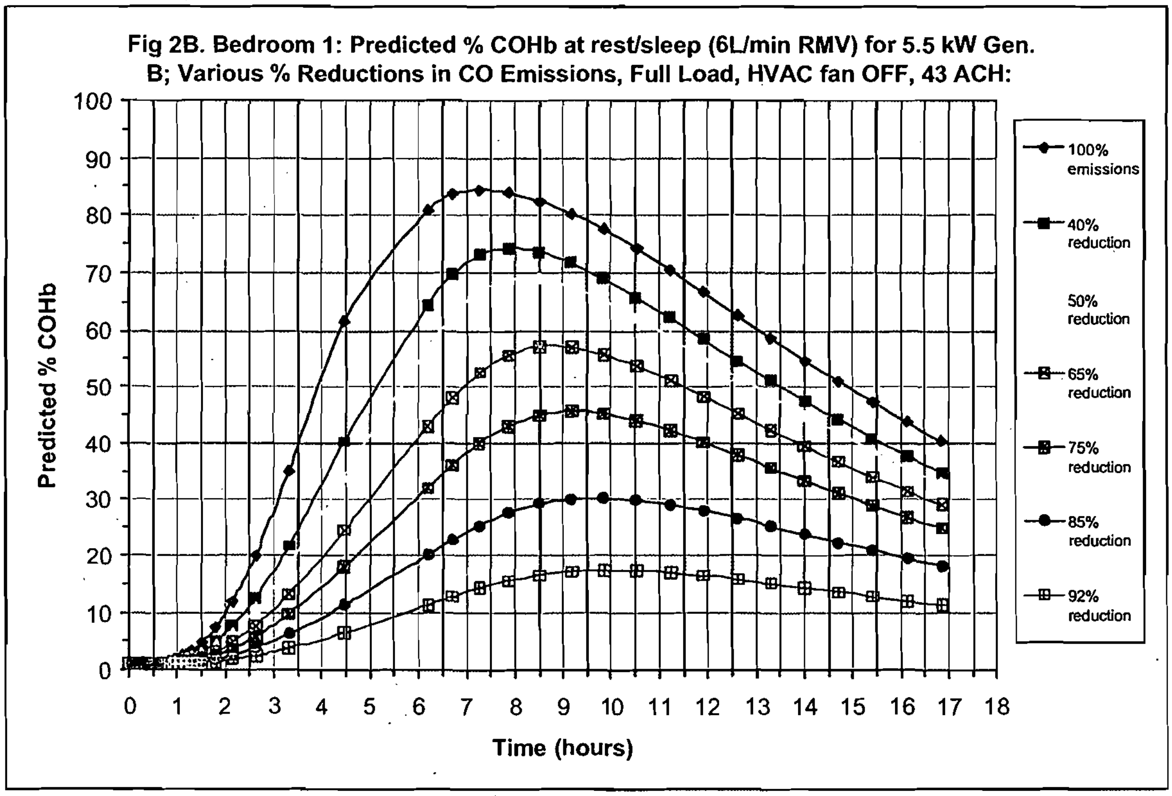


Fig 2B. Bedroom 1: Predicted % COHb at rest/sleep (6L/min RMV) for 5.5 kW Gen. B; Various % Reductions in CO Emissions, Full Load, HVAC fan OFF, 43 ACH:
Predicted % COHb
Time (hours)
100% emissions
40% reduction
50% reduction
65% reduction
75% reduction
85% reduction
92% reduction

**Table 1. Summary of % COHb Predictions at Selected % Reductions of Generator Full Load CO Emission Rate, 2,100,000 cc/hr :Times (h) of Attainment, Duration and Decline from Specific % COHb Levels**

| % emissions reduction | HVAC FAN | Low-Moderate Activity (15 L/min RMV) | >70% COHb | | | 60% COHb | | | 50% COHb | | | 40% COHb | | | 30% COHb | | | 20% COHb | | | 10% COHb | | | HS Prognosis (assuming victims remain in locations) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | |
| 92% | ON | Bedroom1 | NA | NA | NA | NA | NA | NA | NA | NA | NA | 4.60 | 8.50 | 3.90 | 3.40 | 10.25 | 6.85 | 2.40 | 12.21 | 9.81 | 1.60 | 15.40 | 13.80 | Serious Poisoning: DNS probable/Death possible- |
| | | Kitchen | NA | NA | NA | NA | NA | NA | NA | NA | NA | 4.60 | 8.50 | 3.90 | 3.40 | 10.25 | 6.85 | 2.40 | 12.21 | 9.81 | 1.60 | 15.40 | 13.80 | Serious Poisoning: DNS probable/Death possible- |
| | | Basement | NA | NA | NA | NA | NA | NA | 4.30 | 7.40 | 3.10 | 2.90 | 8.80 | 5.90 | 2.20 | 10.40 | 8.20 | 1.54 | 12.30 | 10.76 | 0.92 | 15.54 | 14.62 | Serious Poisoning: DNS probable/Death possible- |
| | OFF | Bedroom1 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 5.80 | 10.80 | 5.00 | 3.80 | 14.70 | 10.90 | *Mild to moderate poisoning - lower possibility of DNS* |
| | | Kitchen | NA | NA | NA | NA | NA | NA | 5.95 | 7.40 | 1.45 | 4.10 | 9.15 | 5.05 | 3.15 | 10.70 | 7.55 | 2.40 | 12.60 | 10.20 | 1.60 | 15.80 | 14.20 | Serious Poisoning: DNS probable/Death possible- |
| | | Basement | NA | NA | NA | 3.10 | 7.50 | 4.40 | 2.40 | 8.60 | 6.20 | 1.90 | 9.80 | 7.90 | 1.55 | 11.40 | 9.85 | 1.20 | 13.30 | 12.10 | 0.75 | 16.49 | 15.74 | Death likely |
| 85% | ON | Bedroom1 | NA | NA | NA | 4.75 | 7.50 | 2.75 | 3.50 | 9.00 | 5.50 | 2.60 | 10.30 | 7.70 | 2.20 | 11.80 | 9.60 | 1.70 | 13.80 | 12.10 | 1.20 | 17.00 | 15.80 | Serious Poisoning: DNS probable/Death possible- |
| | | Kitchen | NA | NA | NA | 4.75 | 7.50 | 2.75 | 3.50 | 9.00 | 5.50 | 2.60 | 10.30 | 7.70 | 2.20 | 11.80 | 9.60 | 1.70 | 13.80 | 12.10 | 1.20 | 17.00 | 15.80 | Serious Poisoning: DNS probable/Death possible- |
| | | Basement | 4.60 | 6.50 | 1.90 | 2.75 | 7.25 | 4.50 | 2.20 | 9.10 | 6.90 | 1.75 | 10.30 | 8.55 | 1.40 | 11.80 | 10.40 | 1.00 | 13.80 | 12.80 | 0.60 | 17.00 | 16.40 | Death likely |
| | OFF | Bedroom1 | NA | NA | NA | NA | NA | NA | NA | NA | NA | 7.50 | 9.20 | 1.70 | 5.40 | 11.25 | 5.85 | 4.00 | 13.50 | 9.50 | 2.80 | 17.00 | 14.20 | Mild to moderate poisoning - lower possibility of DNS |
| | | Kitchen | NA | NA | NA | 4.00 | 8.10 | 4.10 | 3.20 | 9.40 | 6.20 | 2.60 | 10.75 | 8.15 | 2.15 | 12.30 | 10.15 | 1.70 | 14.25 | 12.55 | 1.20 | 17.50 | 16.30 | Serious Poisoning: DNS probable/Death possible- |
| | | Basement | 2.20 | 7.70 | 5.50 | 1.75 | 8.80 | 7.05 | 1.50 | 9.95 | 8.45 | 1.25 | 11.25 | 10.00 | 1.00 | 12.75 | 11.75 | 0.75 | 14.70 | 13.95 | 0.50 | 18.00 | 17.50 | Death likely |
| 75% | ON | Bedroom1 | 7.50 | 7.60 | 0.10 | 2.75 | 8.80 | 6.05 | 2.30 | 10.10 | 7.80 | 1.80 | 11.50 | 9.70 | 1.60 | 13.10 | 11.50 | 1.30 | 15.00 | 13.70 | 0.90 | 18.00 | 17.10 | Death likely |
| | | Kitchen | 4.00 | 7.60 | 3.60 | 2.75 | 8.80 | 6.05 | 2.30 | 10.10 | 7.80 | 1.80 | 11.50 | 9.70 | 1.60 | 13.10 | 11.50 | 1.30 | 15.00 | 13.70 | 0.90 | 18.00 | 17.10 | Death likely |
| | | Basement | 2.20 | 7.76 | 5.56 | 1.70 | 8.90 | 7.20 | 1.40 | 10.20 | 8.80 | 1.20 | 11.55 | 10.35 | 0.90 | 13.10 | 12.20 | 0.70 | 15.00 | 14.30 | 0.40 | 18.00 | 17.60 | Death likely |
| | OFF | Bedroom1 | NA | NA | NA | NA | NA | NA | 6.00 | 9.50 | 3.50 | 4.80 | 11.25 | 6.45 | 4.00 | 12.95 | 8.95 | 3.20 | 15.00 | 11.80 | 2.40 | 18.00 | 15.60 | Serious Poisoning: DNS probable/Death possible- |
| | | Kitchen | 3.25 | 8.10 | 4.85 | 2.60 | 9.40 | 6.80 | 2.25 | 10.60 | 8.35 | 1.95 | 11.90 | 9.95 | 1.65 | 13.55 | 11.90 | 1.30 | 15.55 | 14.25 | 0.90 | 18.00 | 17.10 | Death likely |
| | | Basement | 1.40 | 8.75 | 7.35 | 1.20 | 9.90 | 8.70 | 1.05 | 11.20 | 10.15 | 0.95 | 12.45 | 11.50 | 0.75 | 14.00 | 13.25 | 0.60 | 15.80 | 15.20 | 0.35 | 18.00 | 17.65 | Death likely |
| 65% | ON | Bedroom1 | 2.70 | 9.00 | 6.30 | 2.20 | 9.75 | 7.55 | 1.80 | 11.00 | 9.20 | 1.60 | 12.25 | 10.65 | 1.40 | 12.80 | 11.40 | 1.10 | 15.80 | 14.70 | 0.75 | 18.00 | 17.25 | Death likely |
| | | Kitchen | 2.70 | 9.00 | 6.30 | 2.20 | 9.75 | 7.55 | 1.80 | 11.00 | 9.20 | 1.60 | 12.25 | 10.65 | 1.40 | 12.80 | 11.40 | 1.10 | 15.80 | 14.70 | 0.75 | 18.00 | 17.25 | Death likely |
| | | Basement | 1.55 | 8.50 | 6.95 | 1.30 | 9.75 | 8.45 | 1.10 | 11.00 | 9.90 | 0.95 | 12.30 | 11.35 | 0.75 | 12.90 | 12.15 | 0.55 | 15.80 | 15.25 | 0.35 | 18.00 | 17.65 | Death likely |
| | OFF | Bedroom1 | NA | NA | NA | 6.00 | 9.00 | 3.00 | 4.75 | 10.75 | 6.00 | 4.00 | 12.20 | 8.20 | 3.80 | 13.80 | 10.00 | 2.75 | 15.90 | 13.15 | 2.10 | 18.00 | 15.90 | Serious Poisoning: DNS probable/Death possible- |
| | | Kitchen | 2.50 | 8.90 | 6.40 | 2.10 | 10.20 | 8.10 | 1.80 | 11.45 | 9.65 | 1.60 | 12.75 | 11.15 | 1.40 | 14.35 | 12.95 | 1.30 | 16.15 | 14.85 | 0.80 | 18.00 | 17.20 | Death likely |
| | | Basement | 1.10 | 9.50 | 8.40 | 1.00 | 10.70 | 9.70 | 1.80 | 11.90 | 10.10 | 0.70 | 13.20 | 12.50 | 0.60 | 14.70 | 14.10 | 0.50 | 16.75 | 16.25 | 0.30 | 18.00 | 17.70 | Death likely |

Table 1 continued. Summary of % COHb Predictions at Selected % Reductions of Generator Full Load CO Emission Rate, 2,100,000 cc/hr :Times (h) of Attainment, Duration and Decline from Specific % COHb Levels

| % emissions reduction | HVAC FAN | Low-Moderate Activity (15 L/min RMV) | >70% COHb | | | 60% COHb | | | 50% COHb | | | 40% COHb | | | 30% COHb | | | 20% COHb | | | 10% COHb | | | HS Prognosis (assuming victims remain in locations) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | |
| 50% | ON | Bedroom1 | 2.00 | 9.30 | 7.30 | 1.70 | 10.50 | 8.80 | 1.50 | 11.80 | 10.30 | 1.30 | 13.20 | 11.90 | 1.15 | 14.25 | 13.10 | 0.90 | 16.60 | 15.70 | 0.70 | 18.00 | 17.30 | Death likely |
| | | Kitchen | 2.00 | 9.30 | 7.30 | 1.70 | 10.50 | 8.80 | 1.50 | 11.80 | 10.30 | 1.30 | 13.20 | 11.90 | 1.15 | 14.25 | 13.10 | 0.90 | 16.60 | 15.70 | 0.70 | 18.00 | 17.30 | Death likely |
| | | Basement | 1.20 | 9.40 | 8.20 | 1.00 | 10.60 | 9.60 | 0.80 | 11.90 | 11.10 | 0.75 | 13.30 | 12.55 | 0.60 | 14.30 | 13.70 | 0.45 | 16.60 | 16.15 | 0.30 | 18.00 | 17.70 | Death likely |
| | OFF | Bedroom1 | 6.10 | 8.50 | 2.40 | 4.50 | 10.30 | 5.80 | 3.80 | 11.70 | 7.90 | 3.40 | 13.20 | 9.80 | 2.90 | 14.75 | 11.85 | 2.40 | 16.80 | 14.40 | 1.80 | 18.00 | 16.20 | Death likely |
| | | Kitchen | 1.95 | 9.80 | 7.85 | 1.70 | 11.10 | 9.40 | 1.50 | 12.30 | 10.80 | 1.40 | 13.60 | 12.20 | 1.70 | 15.20 | 13.50 | 0.90 | 17.00 | 16.10 | 0.70 | 18.00 | 17.30 | Death likely |
| | | Basement | 0.90 | 10.40 | 9.50 | 0.75 | 11.50 | 10.75 | 0.70 | 12.75 | 12.05 | 0.60 | 14.10 | 13.50 | 0.50 | 15.60 | 15.10 | 0.40 | 18.00 | 17.60 | 0.30 | 18.00 | 17.70 | Death likely |
| 40% | ON | Bedroom1 | 1.75 | 9.75 | 8.00 | 1.55 | 11.05 | 9.50 | 1.40 | 12.15 | 10.75 | 1.20 | 13.60 | 12.40 | 1.10 | 15.20 | 14.10 | 0.80 | 17.10 | 16.30 | 0.60 | 18.00 | 17.40 | Death likely |
| | | Kitchen | 1.75 | 9.75 | 8.00 | 1.55 | 11.05 | 9.50 | 1.40 | 12.15 | 10.75 | 1.20 | 13.60 | 12.40 | 1.10 | 15.20 | 14.10 | 0.80 | 17.10 | 16.30 | 0.60 | 18.00 | 17.40 | Death likely |
| | | Basement | 1.10 | 9.80 | 8.70 | 0.85 | 11.10 | 10.25 | 0.75 | 12.30 | 11.55 | 0.60 | 13.60 | 13.00 | 0.50 | 14.20 | 13.70 | 0.40 | 17.20 | 16.80 | 0.25 | 18.00 | 17.75 | Death likely |
| | OFF | Bedroom1 | 5.20 | 9.25 | 4.05 | 4.00 | 10.80 | 6.80 | 3.50 | 12.25 | 8.75 | 3.10 | 13.60 | 10.50 | 2.70 | 15.20 | 12.50 | 2.30 | 17.10 | 14.80 | 1.75 | 18.00 | 16.25 | Death likely |
| | | Kitchen | 1.70 | 10.25 | 8.55 | 1.50 | 11.50 | 10.00 | 1.40 | 12.70 | 11.30 | 1.20 | 14.10 | 12.90 | 1.10 | 15.60 | 14.50 | 0.85 | 17.50 | 16.65 | 0.60 | 18.00 | 17.40 | Death likely |
| | | Basement | 0.80 | 10.75 | 9.95 | 0.70 | 12.00 | 11.30 | 0.60 | 13.20 | 12.60 | 0.51 | 14.50 | 13.99 | 0.45 | 16.00 | 15.55 | 0.30 | 18.00 | 17.70 | 0.25 | 18.00 | 17.75 | Death likely |
| 0% | ON | Bedroom1 | 1.35 | offscale | NA | 1.20 | offscale | NA | 1.10 | offscale | NA | 0.90 | offscale | NA | 0.80 | offscale | NA | 0.70 | offscale | NA | 0.50 | offscale | NA | Death likely |
| | | Kitchen | 1.35 | offscale | NA | 1.20 | offscale | NA | 1.10 | offscale | NA | 0.90 | offscale | NA | 0.80 | offscale | NA | 0.70 | offscale | NA | 0.50 | offscale | NA | Death likely |
| | | Basement | 0.70 | offscale | NA | 0.60 | offscale | NA | 0.55 | offscale | NA | 0.45 | offscale | NA | 0.40 | offscale | NA | 0.30 | offscale | NA | 0.20 | offscale | NA | Death likely |
| | OFF | Bedroom1 | 3.55 | 10.30 | 6.75 | 3.00 | 12.25 | 9.25 | 2.75 | 13.50 | 10.75 | 0.25 | 14.90 | 14.65 | 2.25 | 16.50 | 14.25 | 1.80 | 18.00 | 16.20 | 1.00 | 18.00 | 17.00 | Death likely |
| | | Kitchen | 1.80 | 11.50 | NA | 1.20 | 12.20 | 11.00 | 1.11 | 14.00 | 12.89 | 0.90 | 15.25 | 14.35 | 0.80 | 16.90 | 16.10 | 0.70 | 18.00 | 17.30 | 0.50 | 18.00 | 17.50 | Death likely |
| | | Basement | 0.55 | offscale | NA | 0.50 | offscale | NA | 0.48 | offscale | NA | 0.40 | offscale | NA | 0.30 | offscale | NA | 0.25 | offscale | NA | 0.20 | offscale | NA | Death likely |

Note 1: with HVAC fan ON all non-basement areas have virtually identical CO (and COHb) profiles

Note 2: with HVAC fan OFF, the CO (and COHb) profiles decrease with increasing distance from basement location of generator source

Note 3:"Fall below" values of 18 hours are at the limit of the modeled data so associated duration values are likely underestimates

Table 2. Summary of Predicted % COHb Data for Sleeping Bedroom Occupants (RMV = 6 L/min) at Various % Reductions of Generator B Full Load CO Emission Rate, 2,100,000 cc/hr* : Times (h) of

| % emissions reduction | HVAC FAN | Low-Moderate Activity (15 L/min RMV) | >70% COHb | | | 60% COHb | | | 50% COHb | | | 40% COHb | | | 30% COHb | | | 20% COHb | | | 10% COHb | | | HS Prognosis (assuming victims remain in locations) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | attain | fall below | Duration | |
| 92% | ON | Bedroom1 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 5.80 | 10.60 | 4.80 | 4.25 | 15.25 | 11.00 | 2.60 | >18 | >15 | Mild to moderate poisoning -lower possibility of DNS |
| | OFF | Bedroom1 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 5.50 | >17 | >12 | Mild to moderate poisoning -lower possibility of DNS |
| 85% | ON | Bedroom1 | NA | NA | NA | NA | NA | NA | 5.75 | 9.60 | 3.85 | 4.65 | 11.90 | 7.25 | 3.75 | 14.50 | 10.75 | 2.80 | >18 | >17 | 1.90 | >18 | >12 | Serious Poisoning: DNS probable/Death possible- |
| | OFF | Bedroom1 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 9.20 | 10.40 | 1.20 | 6.20 | 16.10 | 9.90 | 4.20 | >18 | >14 | Mild to moderate poisoning -lower possibility of DNS |
| 75% | ON | Bedroom1 | 5.80 | 7.80 | NA | 4.75 | 9.70 | 4.95 | 4.00 | 11.50 | 7.50 | 3.40 | 13.50 | 10.10 | 2.65 | 16.10 | 13.45 | 2.15 | >18 | >16 | 1.40 | >18 | >16 | Death likely |
| | OFF | Bedroom1 | NA | NA | NA | NA | NA | NA | NA | NA | NA | 7.25 | 12.00 | 4.75 | 5.90 | 15.00 | 9.10 | 4.75 | >18 | >13 | 3.40 | >18 | >14 | Serious Poisoning: DNS probable/Death possible- |
| 65% | ON | Bedroom1 | 4.50 | 8.90 | 4.40 | 3.80 | 10.55 | 6.75 | 3.15 | 12.30 | 9.15 | 2.60 | 14.40 | 11.80 | 2.25 | 16.85 | 14.60 | 1.75 | >18 | >16 | 1.20 | >18 | >17 | Death likely |
| | OFF | Bedroom1 | NA | NA | NA | NA | NA | NA | 6.90 | 11.50 | 4.60 | 5.90 | 13.90 | 8.00 | 4.95 | 16.60 | 11.65 | 4.00 | >18 | >14 | 2.90 | >18 | >15 | Serious Poisoning: DNS probable/Death possible- |
| 50% | ON | Bedroom1 | 3.45 | 9.80 | 6.35 | 2.80 | 11.45 | 8.65 | 2.45 | 13.20 | 10.75 | 2.20 | 15.20 | 13.00 | 1.80 | 17.75 | 15.95 | 1.50 | >18 | >17.5 | 1.00 | >18 | >17 | Death likely |
| | OFF | Bedroom1 | NA | NA | NA | 6.45 | 11.00 | 4.55 | 5.70 | 13.00 | 7.30 | 4.90 | 15.20 | 10.30 | 4.15 | 17.60 | 13.45 | 3.45 | >18 | >14 | 2.55 | >18 | >15 | Death likely |
| 40% | ON | Bedroom1 | 2.80 | 10.25 | 7.45 | 2.50 | 11.85 | 9.35 | 2.25 | 13.60 | 11.35 | 2.00 | 15.50 | 13.50 | 1.65 | 18.00 | 16.35 | 1.40 | >18 | >17 | 0.90 | >18 | >17 | Death likely |
| | OFF | Bedroom1 | 6.70 | 9.65 | 2.95 | 5.85 | 11.70 | 5.85 | 5.15 | 13.50 | 8.35 | 4.45 | 15.55 | 11.10 | 3.80 | >18 | >17 | 3.25 | >18 | >15 | 2.40 | >18 | >15 | Death likely |
| 0% | ON | Bedroom1 | 1.35 | 11.55 | 10.20 | 1.20 | 13.20 | 12.00 | 1.00 | 14.90 | 13.90 | 0.85 | 16.40 | 15.55 | 0.70 | >18 | >17 | 0.55 | >18 | >17 | 0.40 | >18 | >17 | Death likely |
| | OFF | Bedroom1 | 5.15 | 11.25 | 6.10 | 4.45 | 13.10 | 8.65 | 3.90 | 14.80 | 10.90 | 3.50 | 16.70 | 13.20 | 3.10 | >18 | )16 | 2.60 | >18 | >15 | 2.00 | >18 | >16 | Death likely |

* assumes 6h running time for a full tank of gasoline

# TAB R

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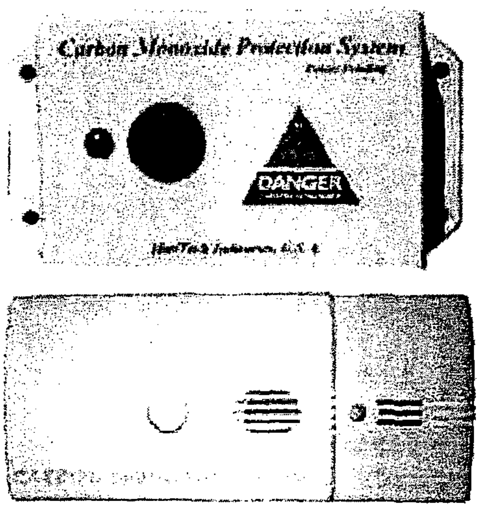
**Carbon Monoxide Protection System** (COPS) (PATENT PENDING):

CO alarms alone are insufficient protection against carbon monoxide poisoning -- the "Silent Killer."

**The Problem:**
CO alarm manufacturers warn that you may not hear nor be able to respond to the alarm due to ambient noise, closed doors, use of alcohol or drugs, because of hearing impairment or due to physical incapacitation. This creates a very dangerous situation for you, your family and crew.

**The Solution:**
MariTech's Carbon Monoxide Protection System (COPS) automatically takes action when carbon monoxide levels trigger the alarm. When the alarm sounds, COPS instantaneously shuts down the CO producing source -- usually the generator.




With **COPS** on 24-hour patrol, you can be confident in knowing the CO producing source will be arrested when you are most at risk....Even if you can't hear or respond to the alarm!

**Features:**
- Self check circuitry to ensure reliability
- Time weighted averaging circuitry virtually eliminates false alarms
- Operates on all 12V DC systems
- Easy installation

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# TAB S

# U.S. CONSUMER PRODUCT SAFETY COMMISSION
## DIRECTORATE FOR ENGINEERING SCIENCES

DEMONSTRATION OF A
REMOTE CARBON MONOXIDE SENSING
AUTOMATIC SHUT OFF DEVICE

FOR PORTABLE GENERATORS

August 2006

Arthur Lee
Electrical Engineer
Division of Electrical Engineering
Directorate for Engineering Sciences

*This report was prepared by the CPSC staff and has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.*

# Executive Summary

Gasoline-powered portable generators are widely used to provide back-up electrical power during extended power outages. One of the exhaust by-products from portable generators is carbon monoxide (CO), a colorless and odorless but highly lethal gas. In recent years, the proliferation and increased availability of portable generators at the consumer level have resulted in an increase in the number of CO related deaths. This increase is particularly evident in areas that have lost electrical power for extended periods due to severe weather.

In an effort to mitigate the CO hazards associated with the use of portable generators, in 2005, the U.S. Consumer Product Safety Commission (CPSC) staff conducted a proof-of-concept demonstration to integrate a CO detection system with a portable generator. The concept utilizes wireless technology combined with CO detection devices and off-the-shelf circuitry designed to provide an automatic shut off feature on portable generators. If elevated levels of CO accumulate in occupied areas of a household, the CO detection device sends a command to shut off the generator, thus eliminating the CO source. The following report details the design and testing of the demonstration system.

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## 1.0 Introduction

Gasoline-powered portable generators are widely used to provide back-up electrical power during extended power outages. The popularity and availability of these devices began to increase during pre-Y2K (year 2000) as consumers prepared for possible long-term power losses associated with the Y2K conversions. Although portable generator sales peaked in 1999*, their relatively low cost and availability at the retail level continued even after year 2000. Following the Northeastern blackout of August 2003, many consumers considered generators to be a necessity in an emergency, similar to candles, flashlights, batteries, and bottled water. Major home improvement chains shipped thousands of additional generators to stores in affected areas within days after power was restored.†

Most portable generators use a single cylinder, gasoline-fueled, internal combustion engine equivalent to a lawnmower engine. Although robust and rugged, these engines are inefficient and contain no emission controls to mitigate harmful exhaust, thus making them significant producers of carbon monoxide (CO), a colorless and odorless but highly lethal gas. Available data show that CO-related deaths occur when portable generators are improperly located in enclosed spaces or inadequately vented locations‡ such as garages or near open windows and doors. Consumers locate generators indoors or close to houses for a number of reasons, including fear of theft and concerns that direct exposure to precipitation may damage the unit.

One concept to address the CO hazard is to incorporate a control system into the generator to shut it off or prevent it from starting if CO levels constitute a significant risk to occupants in an area being monitored. The approach is to use a standard residential CO alarm with a wireless link that will communicate with a transmitter/receiver affixed to the portable generator. In the event that the CO alarm senses elevated concentrations of CO, the wireless link will communicate with, and automatically shut off, the generator.

Figures, illustrations, and test setups shown or descriptions of tests conducted in this report show a generator that has purposely been improperly located in order to evaluate the effectiveness of the experimental system in sensing accumulated CO. The CPSC recommends that portable generators never be operated in a confined space, such as a garage. Portable generators should be operated and maintained as specified by the manufacturer.

### 1.1 CO Alarms

Alarms to detect elevated levels of CO in the home have been available to consumers since the early 1980s. In 1992, Underwriters Laboratories (UL) published the first edition of UL 2034, *Standard for Safety for Single and Multiple Station Carbon Monoxide Alarms*. Initially,

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* Donaldson, Mary, *Portable Generators*, CPSC Memorandum to Janet Buyer, Project Manager, U.S. Consumer Product Safety Commission, Washington, D.C., August 22, 2005.

† *Generators: Power in a Pinch,* Consumer Reports, Consumers Union of U.S., Inc, November 2003.

‡ Marcy, Natalie and Debra Ascone, *Incidents, Deaths, and In-Depth Investigations Associated with Carbon Monoxide and Engine-Driven Tools, 1990-2004,* CPSC Memorandum to Janet L. Buyer, Project Manager, U.S. Consumer Product Safety Commission, Washington, D.C., December 1, 2005.

CO alarms were plagued with reliability challenges, particularly false alarms. In response to these concerns, UL 2034 was modified to improve the reliability of residential CO alarms.

CO alarms allow the detection of elevated levels of CO in a home from fuel burning appliances, as shown in Figure 1. The early detection of elevated levels of CO is critical to ensuring that affected occupants have sufficient time to evacuate, before being overcome by dangerous levels of CO. Some jurisdictions in the U.S. require the installation of CO alarms for homes containing fuel-burning appliances. Others, such as Mecklenburg County in North Carolina, require them in homes regardless of whether they contain fuel-burning appliances in response to CO deaths that occurred in a December 2002 ice storm due to portable generators and burning charcoal. Most homes in the U.S. that use fuel-burning appliances are not required to have CO alarms installed.

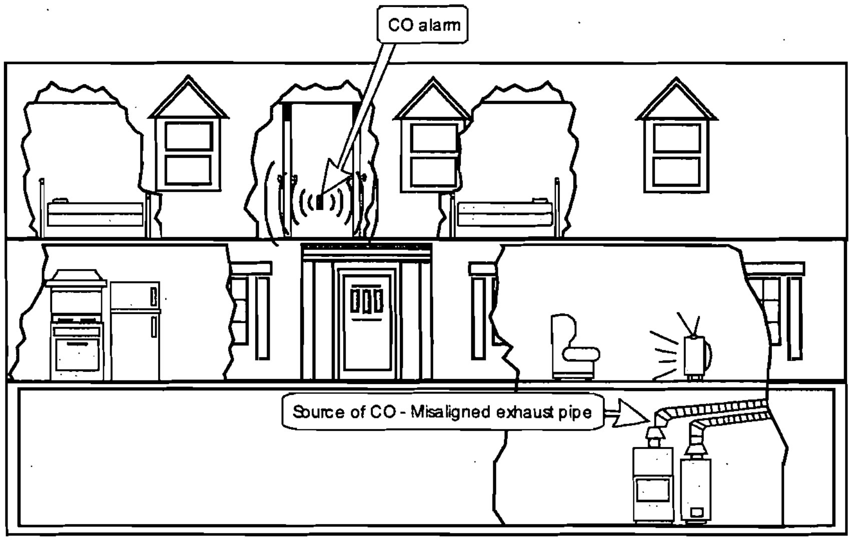


Figure 1. CO alarm helps detect elevated levels of CO in the home

The three basic types of CO sensors used in residential CO alarms are biomimetic, metal oxide, and electrochemical. Biomimetic (chemioptic) sensors are designed to mimic the way the body responds to carbon monoxide. These sensors use gel-coated discs that darken in the presence of CO, thus tripping the alarm. There are several advantages to biomimetic sensors. They are inexpensive and require very little electricity. The sensors typically do not nuisance alarm in the presence of common household gases. However, CO alarms equipped with these sensors may false alarm if there are high or low temperatures and/or relative humidity levels in the home.

The first residential CO alarms on the market used metal oxide or tin oxide sensors. These sensors use heated tin dioxide, which reacts to carbon monoxide, to determine the level of CO. These units use more electricity than the biomimetic or the electrochemical sensors because the tin oxide has to be heated every few minutes. Metal oxide sensors respond quickly to CO, but may sometimes nuisance trip from exposure to common household chemicals. High humidity can also be a problem, since the sensors degrade slightly each time they are exposed to moisture.[§]

Electrochemical technology uses three platinum electrodes in an electrolyte solution. The sensor generates energy when exposed to CO. These alarms respond quickly to CO, but their sensors have a shorter life than the other sensor types.

1.2 Possible Technical Solution for Shutting Off a Portable Generator

Deaths have occurred in scenarios in which portable generators were placed inside or too close to a home, as shown in Figure 2. Since portable generators produce significant amounts of CO, the build-up of lethal concentrations of CO in a home can occur in a short amount of time.


Figure 2. Portable generator located in confined spaces or near an open window

Before sending a shut off signal to the generator, the level of CO in the affected area(s) must be monitored. There are at least two possible techniques to measure the CO produced by the generator. One method is to detect the level of CO in the vicinity of the generator (at the source). If levels near the generator become elevated, an auto shut off device can disable the generator. Another method is to monitor the CO level in the vicinity of the occupants in the home (remote detection). If elevated CO levels are detected in the home, an auto shut off device can disable the generator. There are advantages and disadvantages to each method.

*1.2.1 CO detection at the source*

Mounting a CO detection device on the generator allows fast detection of elevated CO in a confined space as shown in Figure 3. Even though this method may be ideal for fast detection of CO, there are some design obstacles. Generators are typically used outside, which can cause the CO sensors to become contaminated or dirty. The difficulty lies in designing a housing to shield the sensor from contaminants, but which will also allow air to enter the sensor chamber. In addition to withstanding the environmental conditions, the electronics and sensor(s) must also

[§] Phillips WG. Carbon monoxide detectors: What you need to know. Popular Science. 1998 Jan:76-81 withstand the conditions produced from the generator, such as continuous vibration present with most generator engines.

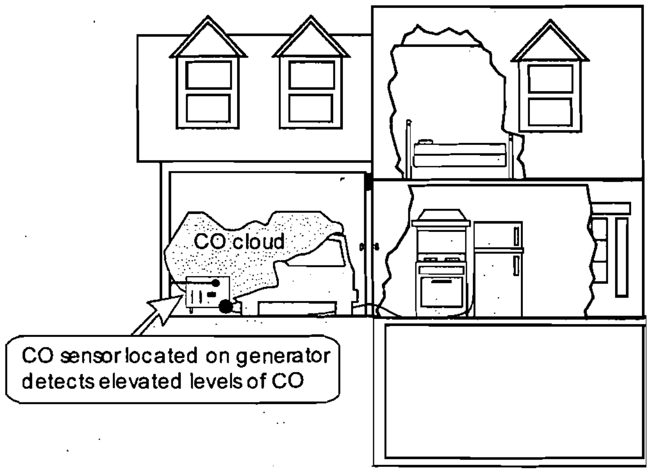
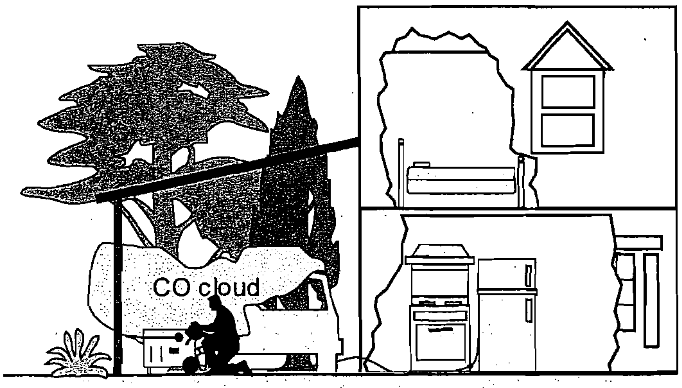



Figure 3. Portable generator located in the garage of an attached home

The location of the sensor on the generator and the sensor's sensitivity will be critical in preventing false alarms and still allowing the sensor to detect elevated levels of CO. Depending on objects adjacent to the generator, such as a wall, bushes, car, or shed, small pockets of CO may be trapped. An effective CO alarm should be able to discriminate between a small temporary pocket of CO and a potentially lethal cloud. Small pockets of CO may cause the sensor to alarm and shut off the generator even though CO has not entered the home. Wind direction may also cause the CO sensor to shut off the generator, causing nuisance tripping of the generator.

Even though CO levels are not elevated in the home, CO levels may be elevated near the generator, which may present a risk to the consumer. The generator may be located outside in a semi-confined space, such as a carport, that may cause elevated levels of CO only near the generator. The consumer may be within the hazardous CO cloud during refueling or operation of the generator as shown in Figure 4.




CO cloud for illustration purposes. CO is colorless and odorless

Figure 4. Portable generator located outside in a semi-confined space

*1.2.2 Remote CO detection*

Locating a CO sensor remotely allows monitoring the level of CO where the concentrations are most critical, as shown in Figure 5. One advantage of placing the CO sensor in the living space near the occupants is that it reduces the likelihood of the sensor being compromised by exposure to harsh environments. The alarm will also be more audible to the occupants, alerting them to elevated levels of CO. If the sensor unit contains a visual display of CO concentration, such as parts per million (ppm), it will provide occupants with an indication of the level of CO to determine if it is rising or stable. If occupants observe rising CO levels, they could remotely shut off the generator without having to approach it, thereby potentially reducing exposure to higher CO levels that may be present closer to the generator. A disadvantage to remote sensing is that the CO sensing unit might not be located in the same part of the house in which occupants are located. In such a case, the level of CO near the occupants could be elevated, but the CO sensing unit may not detect it because it is in a different part of the home.

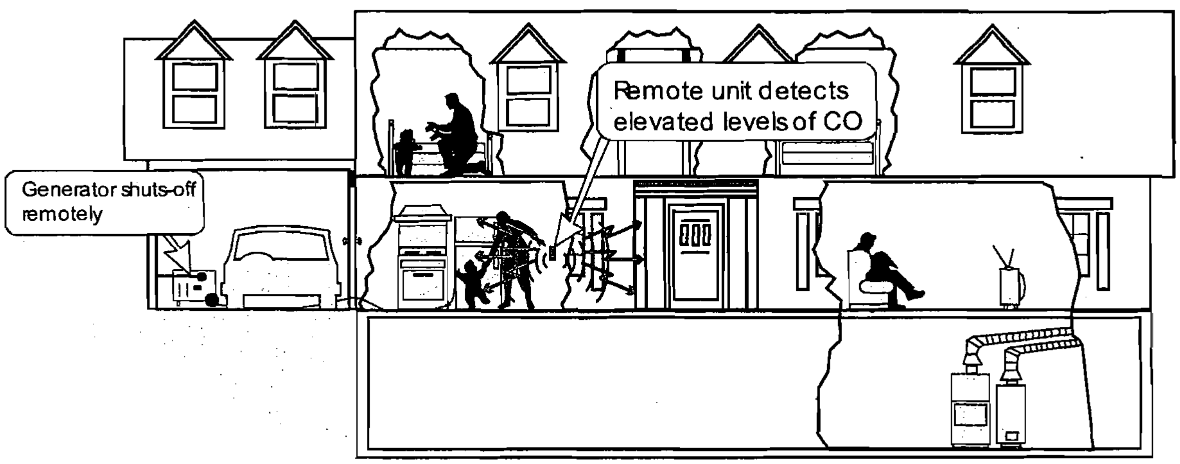



Figure 5. CO detection device to remotely shut off the generator

Both types of CO detection/shut off concepts, either at the source or remotely, would require the CO sensing unit to operate with a battery or secondary power supply during a power outage. However, the "source" CO sensor located at the generator could switch to AC generator power once the generator has started.

## 2.0 Wireless Communication with CO Alarms and Portable Generators

CPSC staff evaluated the concept of using a remote CO detection device to detect elevated CO concentrations and remotely shut off the portable generator. In a December 2003 joint effort with the Naval Research Laboratory (NRL) under contract to CPSC (CPSC-I-02-1290), the feasibity of incorporating wireless technology in battery-powered smoke alarms and having the alarms "communicate" with each other was demonstrated.

Under the 2003 contract with NRL, transmitter and receiver circuits were successfully integrated into existing residential smoke alarms using wireless technology. If any smoke alarm activated, it transmitted a signal to the other smoke alarms so that they would activate "sympathetically." Each receiving smoke alarm also acted like a repeater; thus, a smoke alarm that may have been too far away to be activated by the initiating smoke alarm could be activated by a closer smoke alarm that was transmitting an alarm signal. Maximizing battery power was a key factor in selecting the transmitting range and the rate at which the receiver checked for an alarm signal.

The demonstration described in this report uses wireless technology with a CO alarm to trigger a shut off device on the portable generator. The remote CO alarm was designed to initially check the CO level in the home before allowing the occupant to start the generator. This feature may also be beneficial in helping prevent the occupant from restarting the generator when there are elevated levels of CO in the home.

A wireless transmitter that triggers a shut off device on the portable generator was incorporated into a conventional CO alarm. A shut off device was located on the generator where it will shut off the engine in the event of elevated CO levels in the home. Figure 6 shows a block diagram of a remote CO sensing shut off system. The user would be required to depress an enable button before the generator would be allowed to start. The enable button would prevent the operator(s) from starting the generator when an elevated level of CO may already exist in the home.

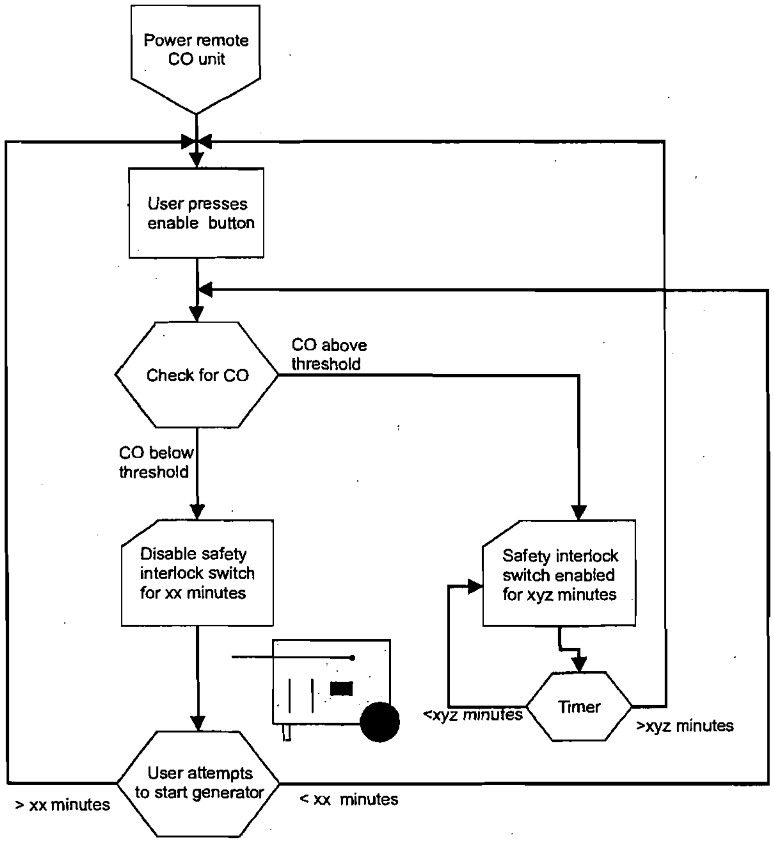



Figure 6. Block diagram of a shut off device on a portable generator

## 2.1 Test Setup and Instrumentation

CPSC staff conducted tests using a UL listed CO alarm, AC-powered with battery back-up and electrochemical sensing, as the sensing device to signal the controls to shut off a generator. For this testing, the CO alarm was powered only from a battery (no AC power) to enhance the portability of the system. The CO alarm also incorporated an interconnect feature that would allow multiple CO alarms to sound when any one of the units alarmed. This feature increases alarm audibility throughout the home. For the purposes of the staff testing, the interconnect signal was used to trigger the wireless transmitter that was installed in the CO alarm.

A data acquisition system consisting of a current meter, an analog-to-digital signal converter (ADC) unit, a gas analyzer, and a computer was used. The current meter was used to measure the load on the generator during the tests. The ADC unit was used to record load current, CO alarm interconnect signal, CO level, and generator operating status (whether or not it was running). The CO alarm and gas analyzer (CO sampling device) were moved to different locations in the home to record CO levels.

Below is a list of the equipment used in the staff testing. CPSC does not endorse the equipment and instrumentation used in the tests nor state that the equipment and instrumentation used are the best or only products for this application. The product and company names listed are trademark or trade names of their respective companies.

| | |
|---|---|
| Alarm Source | Residential Carbon Monoxide Alarm<br>AC powered with 9-volt battery back-up<br>Sensor Type - electrochemical<br>UL listed |
| CO Sampling | NOVA Gas Analysis Equipment<br>Model 310WP<br>Sensor Type – electrochemical<br>Aspirated air sampling<br>Range: 1% of full scale, 0-2000 ppm<br>Response time: 20-30 seconds for 90% of step change<br>Last calibrated – August 2002 |
| Digitizing System | Data Translation<br>Model DT9834<br>16 bit A/D |
| Computer | Laptop<br>3GHz processor<br>1G RAM |
| Current Probe | Fluke<br>Model 80i-110s<br>Rated 10 milliamps to 100 Amps |
| Transmitter and Receiver | Wireless Automator<br>Programmable relays<br>6 relays rated at 3 amps @ 12V |
| High Current Relay | Type - SPDT Form "C" heavy duty dry contacts<br>Contact rating 7A @ 30VDC, 10A @125VAC<br>Input trigger 9-12VDC 30mA |
| Portable Generator | 5250 watt<br>Fuel - Gasoline<br>Pull start |

The transmitter and receiver units were part of an off-the-shelf remote-controlled relay unit that can control power for up to six 5-ampere appliances. The transmitter had three channels with a range of 150 ft. The receiver unit included six relays that were opened or closed by a signal from the transmitter. Depending on which push button(s) was depressed on the transmitter, the receiver unit could operate different relays.

The receiver unit was mounted on the generator to control a relay that was incorporated into the generator ON/OFF circuit as a shut off device. Since the receiver unit could receive multiple programmed signals from transmitters, multiple CO alarm transmitter units could be located throughout a home to increase the number of areas monitored for CO accumulation. Monitored areas might include individual bedrooms and each level of the home. The number of CO transmitter units installed in a home would, in part, depend on the location of occupants in the home, and the size and configuration of the home. Figure 7a shows an example of a small home, which may require only one remote CO unit. A larger home may require multiple remote CO units as shown in Figure 7b. In this example, the master bedroom is separated from the other three bedrooms. A remote CO detection unit would be needed in both areas if each area contained occupants. An additional remote CO unit might also be needed in the family room. For the purposes of this test program, only a single CO alarm transmitter unit was used.

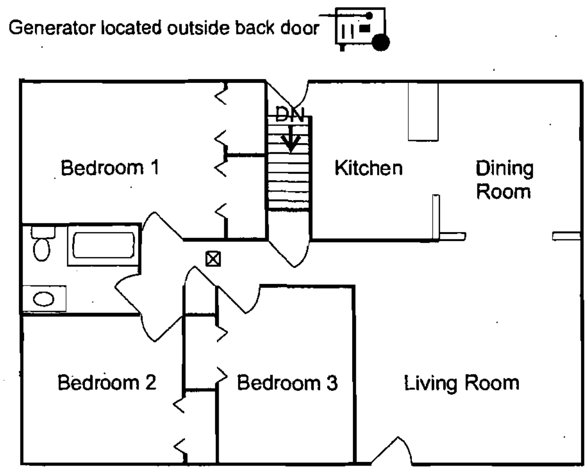



Figure 7a. Example of a CO detection unit in a small home

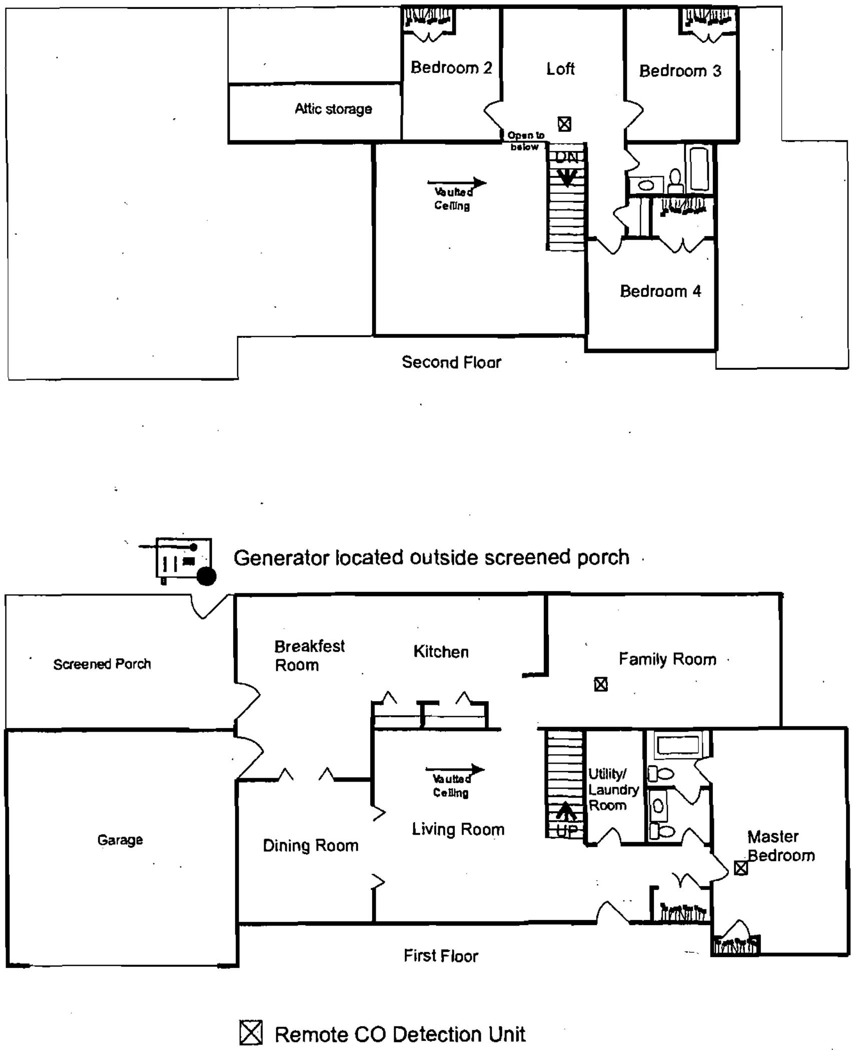



Figure 7b. Example of multiple CO detection units in a larger home

For staff testing, a 3,900 $ft^2$ home was used as the test structure. The home had an attached three car garage. The home had two levels and a basement. Each level was approximately 1,300 $ft^2$. The home contained central heating and air conditioning, which were turned off during the testing. All the external windows and doors were closed during the testing.

2.2 Incorporating a Wireless Transmitter in a CO Alarm

To demonstrate this application using wireless technology, CPSC staff used off-the-shelf universal radio frequency (RF) transmitter and receiver units. The RF transmitter circuit board was removed from its plastic housing and installed in a CO alarm, as shown in Figure 8. The transmitter circuit board was 1.25 inches x 1.5 inches, which allowed it to fit in the 9-volt battery compartment. A separate 9-volt battery terminal was used to power the CO alarm. The transmitter circuitry used one 12-volt battery.

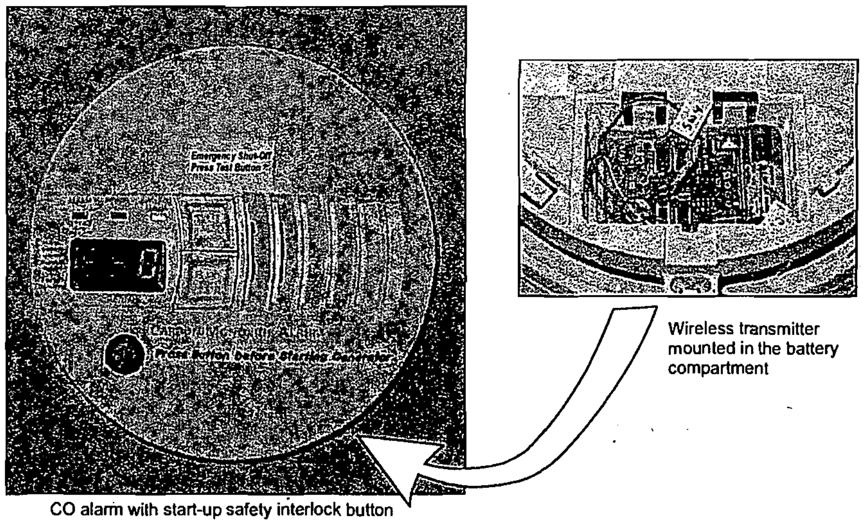



Figure 8. RF transmitter installed in a CO alarm

The interconnect signal on the CO alarm was used to trigger the transmitter, which is normally activated by the pushbuttons on the transmitter. Staff fabricated a circuit to interface the transmitter with the CO alarm's interconnect output signal. Figure 9 shows the schematic of how the wireless circuitry was incorporated into the CO alarm. The transmitter could send two different commands to the receiver. One command would initiate the allowable period for starting up the generator, and the other command was used to shut off the generator if the CO alarm went off.

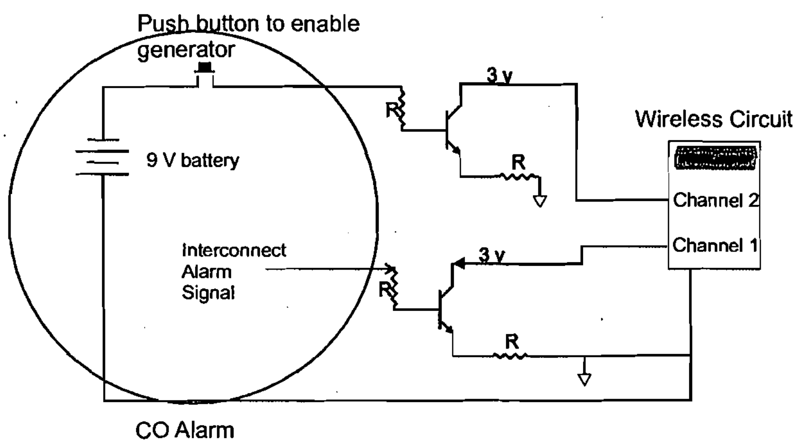



Figure 9. Schematic of CO alarm and RF transmitter

2.3 Incorporating a Wireless Receiver on the Portable Generator

The receiver/shut off unit was installed on a portable generator. The unit contained a wireless receiver, a separate shut off relay, and a rechargeable battery. Figure 9 shows a block diagram for the operation of the receiver unit and its integration with the generator.

The receiver unit is normally in a "stand-by" mode, waiting for a wireless start-up signal from the CO detection unit. The generator start-up sequence begins when the user presses a button on the remote CO detection unit to transmit a start-up signal. When a signal is received, the receiver unit closes relays, which prepares the generator for start-up and operation. The start-up relay is closed for approximately 20 minutes, which gives the user time to go outside to the generator and continue the starting sequence, such as pull starting the engine. When the generator starts, the power to maintain closure of the relay (initially battery power) is replaced by the generator. If 20 minutes has elapsed and the generator has not been started, the relay opens and disables the generator. The user would have to press the start-up button on the CO detection unit again before attempting to start the generator.

Once the generator has been started, if elevated CO levels are detected by the CO detection unit, the CO detection unit transmits an RF signal to the receiver unit. Upon receiving the signal, the receiver unit removes power from the relay, causing it to open and disable the generator. The generator will be disabled until the CO levels drop and the detection unit stops sounding/transmitting. Once the CO levels have declined, the start-up button can be pressed, and the user will be able to start the generator within the 20 minute window.

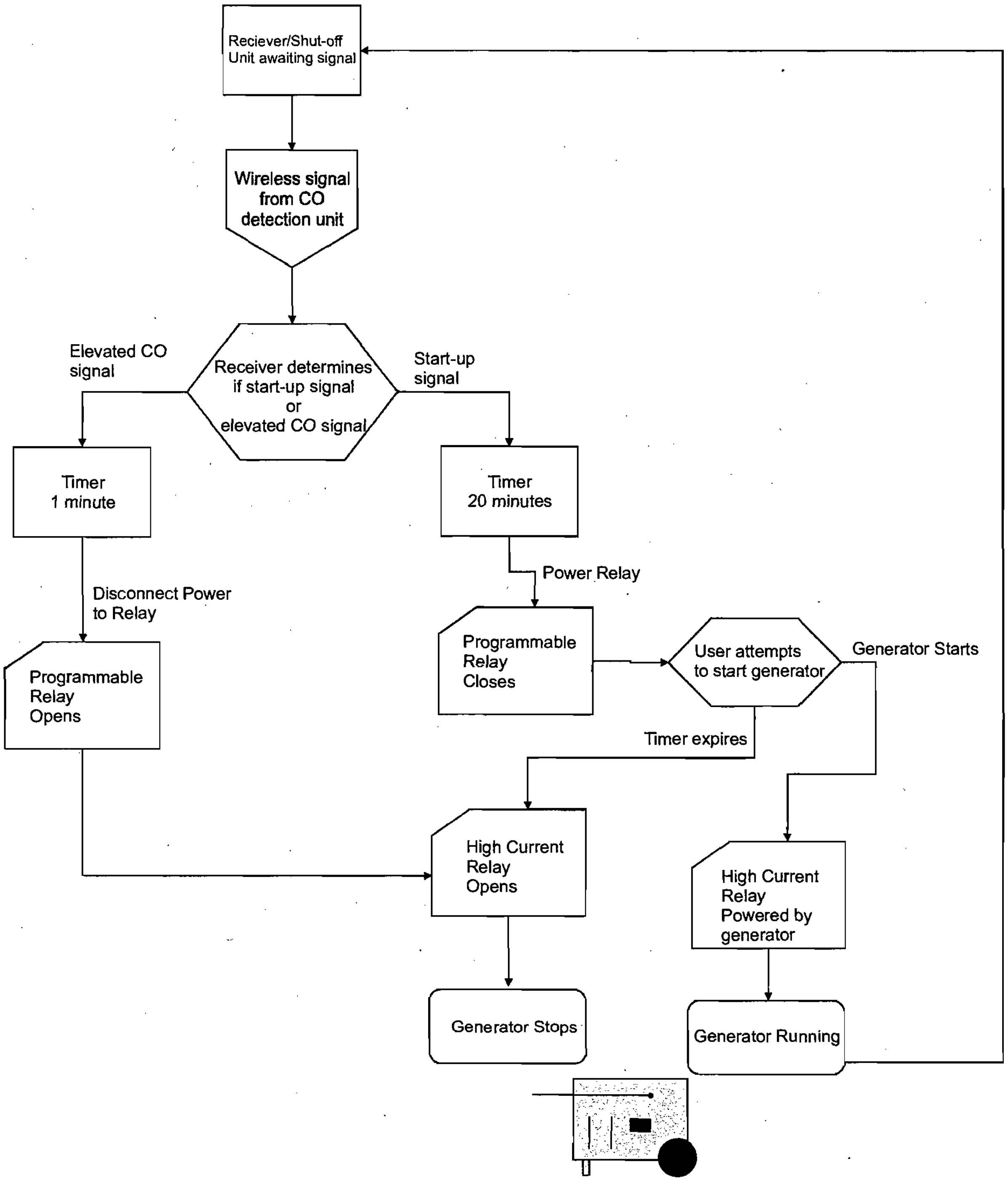
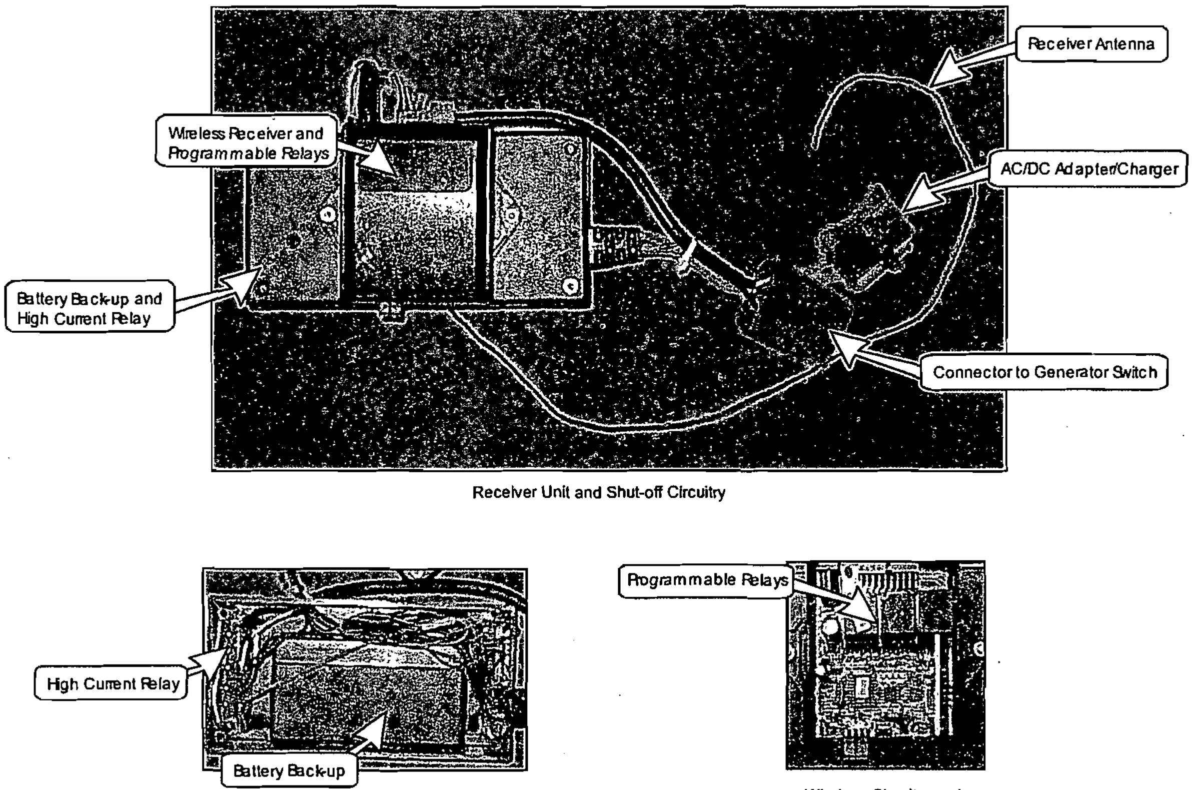



Figure 10. Block diagram of receiver unit operation

The receiver and shut off system were packaged in an 8 x 3 x 2 inch box, which also contained the back-up battery, high current relay, and a small circuit board. The wireless receiver with the programmable relays was mounted on the outside of the box as shown in Figure 11. The wireless receiver had a 10-inch antenna and required 12 volts input to power the circuitry. An AC/DC connector was used to allow charging of the back-up battery by either plugging the adapter into a household 120 VAC receptacle or into the generator's 120 VAC receptacle. Another connector was used to connect the shut off relay to the generator's manual ON/OFF switch. For prototype designing and testing, this set-up allowed easy removal of the receiver/shut off unit. Figure 12 shows the schematic of the wireless circuitry incorporated in the test generator.




Receiver Unit and Shut-off Circuitry

Battery Back-up and High Current Relay

Wireless Circuitry and Programmable Relays

Figure 11. Wireless receiver and shut off unit

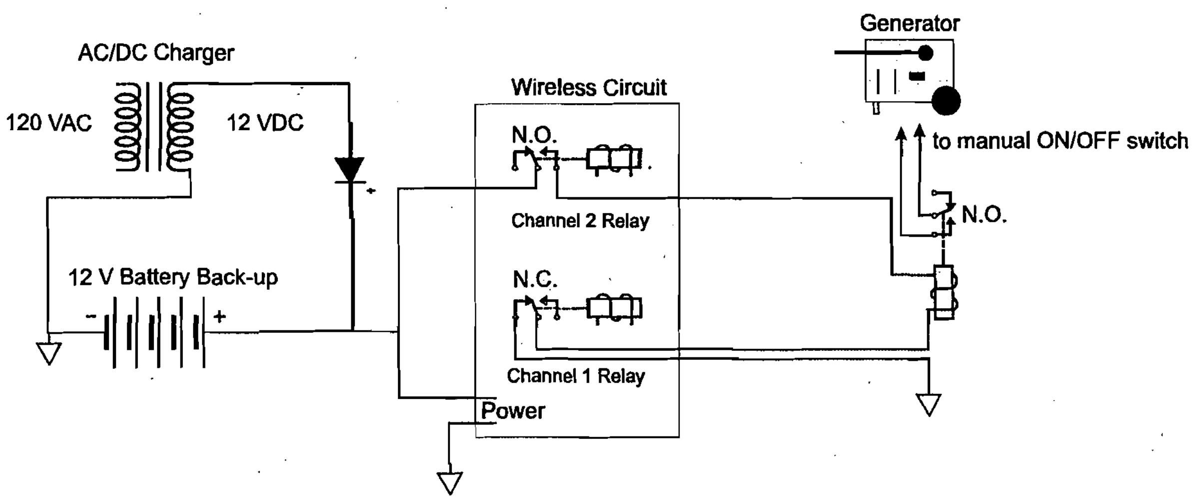



Figure 12. Schematic of shut off unit and generator

The wireless receiver/shut off unit was mounted on the generator and connected to the generator's manual ON/OFF switch as shown in Figure 13. The generator's ON/OFF switch remained in service and allowed the user to shut off the generator by turning the switch to the OFF position. The generator also could not be started unless the switch was in the ON position. The receiver unit's relay was connected in parallel with the manual ON/OFF switch. (The ON/OFF switch is open in the ON position and closed in the OFF position, so either switch can be used to shut off the generator.) This arrangement allowed either the user to manually shut off the generator or the receiver unit to shut off the generator.

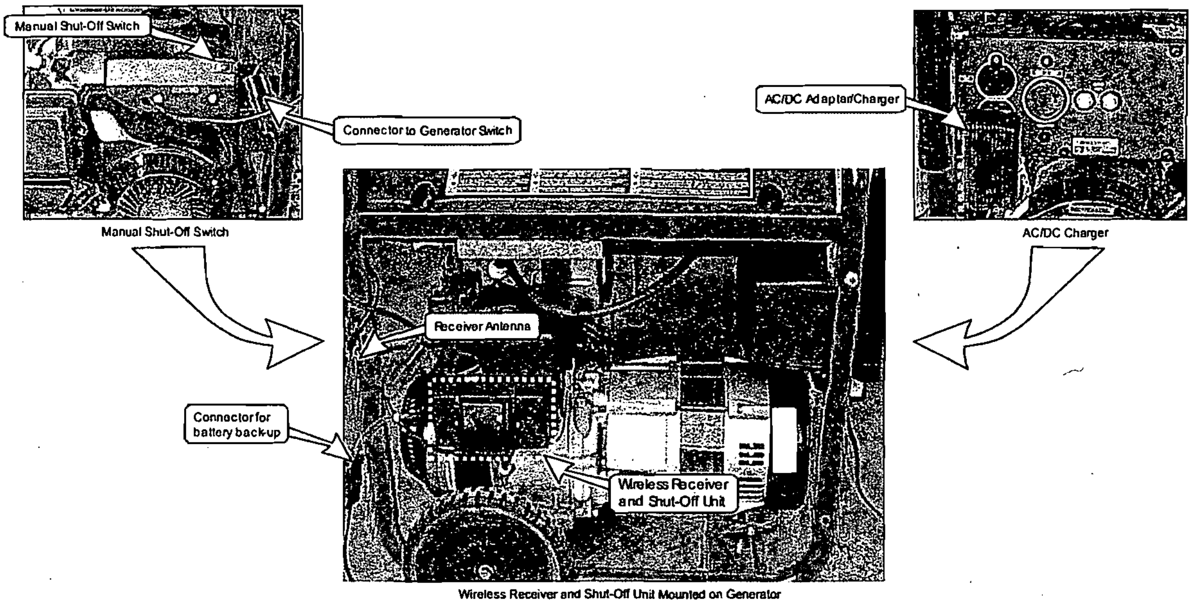



Figure 13. Wireless receiver/shut off unit on the generator

The shut-off relay current capacity was determined by measuring the current through the ON/OFF switch when the switch was turned from ON to OFF with the generator running. The peak current was less than 2 amps, and the pulse width was less than 0.5 seconds. The current through the generator's manual ON/OFF switch was less than the maximum current rating for the high current relay selected for the shut off unit.

## 3.0 Testing of the Remote CO Detection System

Several tests were conducted to determine the functionality of the CO detection and shut off system. The testing was conducted using the test button on the CO detection unit and the receiver unit mounted on the generator. Several tests were conducted to allow the CO detection unit to be exposed to elevated levels of CO and then shut off the generator automatically. The elevated levels of CO were generated by operating the portable generator in a confined space (6993 $ft^3$ garage). As previously noted, testing conducted with the portable generator in the garage was for test purposes only and is not consistent with correct and safe operation of a portable generator. The CPSC recommends against operating a portable generator in a garage. Portable generators should be operated and maintained as specified by the manufacturer.

For all the tests, an AC/DC (120 VAC/5VDC) transformer was plugged into the generator's 120 VAC receptacle and used as a monitoring source to indicate that the generator was running. Figure 14 shows the response of the AC/DC adapter when power is removed. The voltage slowly decays after a delay of approximately 3 seconds. The delay and decay are caused by internal adapter capacitance.

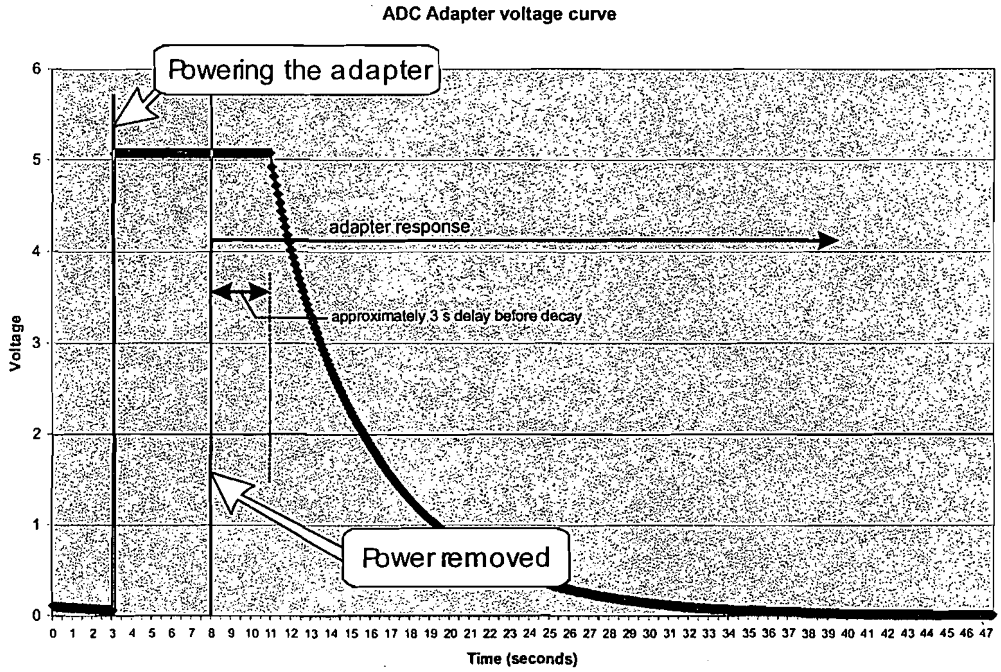



Figure 14. Adapter Response

The NOVA Gas Analyzer used in the testing was last calibrated in 2002 so the measured values were only used for monitoring purposes in the course of these tests. The purpose of using the CO gas analyzer was to roughly monitor the CO build-up during the test. The reading was also used to determine when the CO level in the home had reached near zero before starting the next test. The unit was zeroed before each test. A data acquisition system was used to record CO levels, the CO detection unit's interconnect signal, and the output of the AC/DC transformer plugged into the generator. The sampling rate was 0.1 seconds unless noted otherwise.

3.1 Test Button Testing

Initial testing was conducted using the test button on the CO alarm. This test was conducted outdoors. The CO detection unit was placed approximately 20 feet from the generator. The test button on the CO unit was depressed, which enabled the generator to be started. The generator was started successfully and, after 20 minutes, the relay timed out but remained closed utilizing power from the generator. No external load was connected to the generator.

After 30 minutes, the test button on the CO detection unit was depressed. The receiver unit received the signal and opened the relay, causing the generator to stall and shut off. Figure

15 shows the voltage response curves for the interconnect signal and the generator power shutting off. The sharp peaks show the interconnect signal triggering the wireless transmitter. Approximately 0.5 seconds later, the power at the generator's 120 V receptacle was discontinued. The adapter response delay and decay are also shown in the figure.

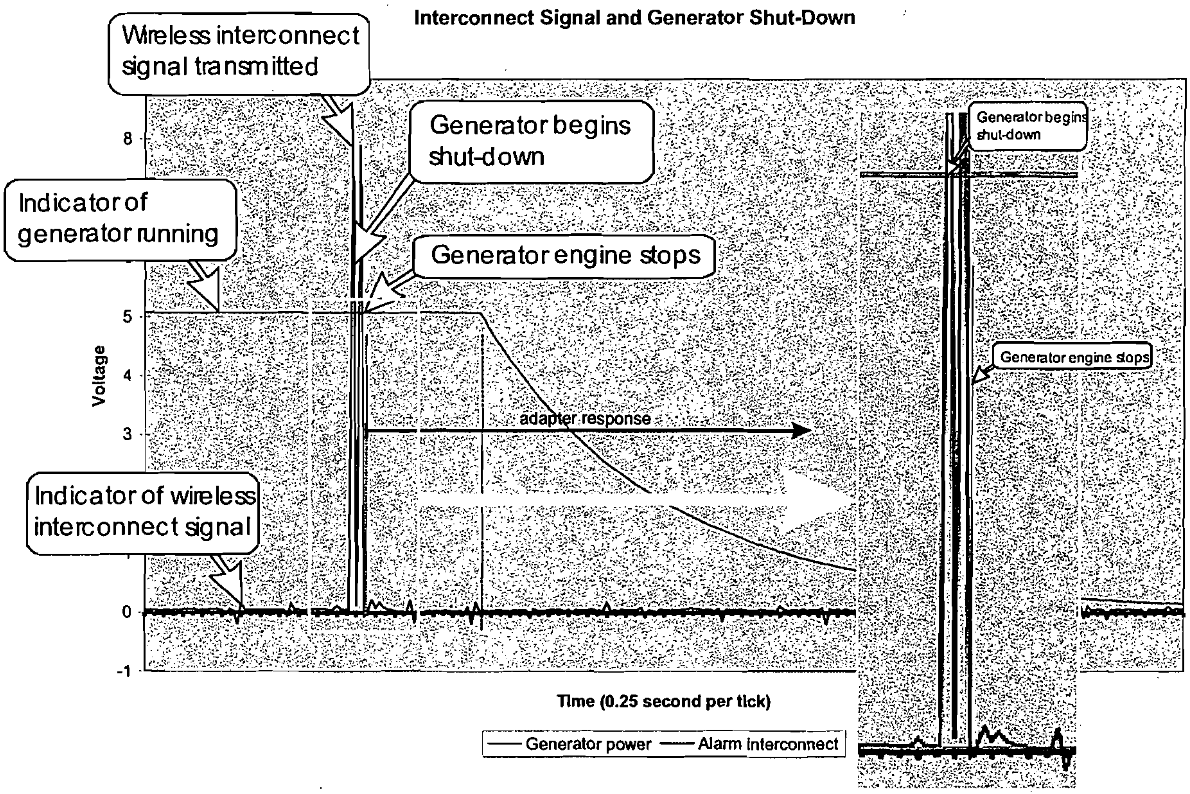



Figure 15. Voltage response for remote shut off using the test button

3.2 Elevated CO Testing

The generator was located in a three car garage attached to a two-story (with basement) single family home. The CO detection unit was placed in various locations in the home for each test. The home has an open floor plan and 9 ft ceilings. The family room has cathedral ceilings to the second floor, and the foyer is two stories high. Together, the first floor, second floor, and basement are approximately 3,900 $ft^2$. The three car garage is approximately 31.5 feet x 18.5 feet x 12 feet high. The generator was placed in the middle bay of the three car garage, and all the garage doors were closed for all the tests. The generator was placed with the exhaust directed towards the middle garage door. The garage did not contain any vehicles, but the miscellaneous items in the garage occupied approximately 1/12 of the garage's volume. The garage has a door leading to a hallway. The adjoining hallway includes an open staircase down to the basement, an interior door to the general living area and an exterior door to the outside.

The home's heating and air conditioning system was off for all the tests. All the windows and external doors were closed for all the tests. During the testing, the ambient temperature varied from 70° F to 76° F, and the winds were variable from 5 to 10 mph.

For the first test, the CO detection unit was placed in the garage near the door to the hallway. The remote detection/shut off unit was approximately 14 feet from the generator and 3-1/2 feet from the floor. The door to the hallway was closed. The test was conducted with no load. The gas analyzer was placed at the same location as the CO detection unit. Figure 16 shows the setup for the testing.

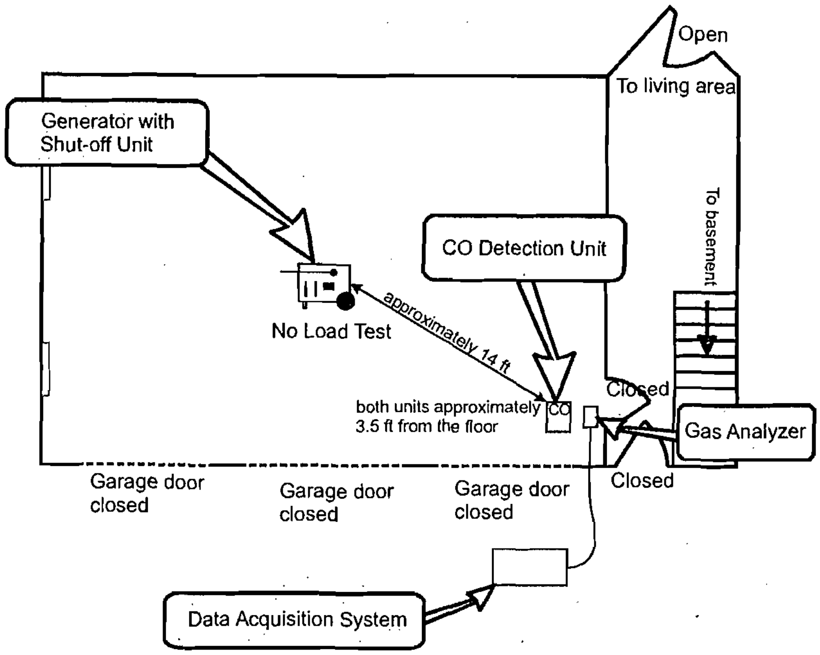



Figure 16. Test 1 set-up with remote CO detection/shut off unit in the garage

The start button on the CO detection unit was depressed, which enabled starting of the generator. The generator was pull-started successfully and the operator monitored the testing from an outdoor location. After the start of the generator, the CO detection unit detected elevated CO levels in approximately 8 minutes. At this time, the CO detection unit transmitted a wireless signal. The receiver unit received the signal and shut off the generator. The gas analyzer indicated approximately 732 ppm, and the CO detection unit's digital display indicated 598 ppm when the generator shut off. Figure 17 shows the interconnect signal from the CO detection unit, the generator running power indicator, and the CO gas analyzer over a 15 second period.

The garage and exterior doors were opened and CO levels were allowed to drop to near zero before the operator re-entered the structure. The gas analyzer was zeroed before the next test.

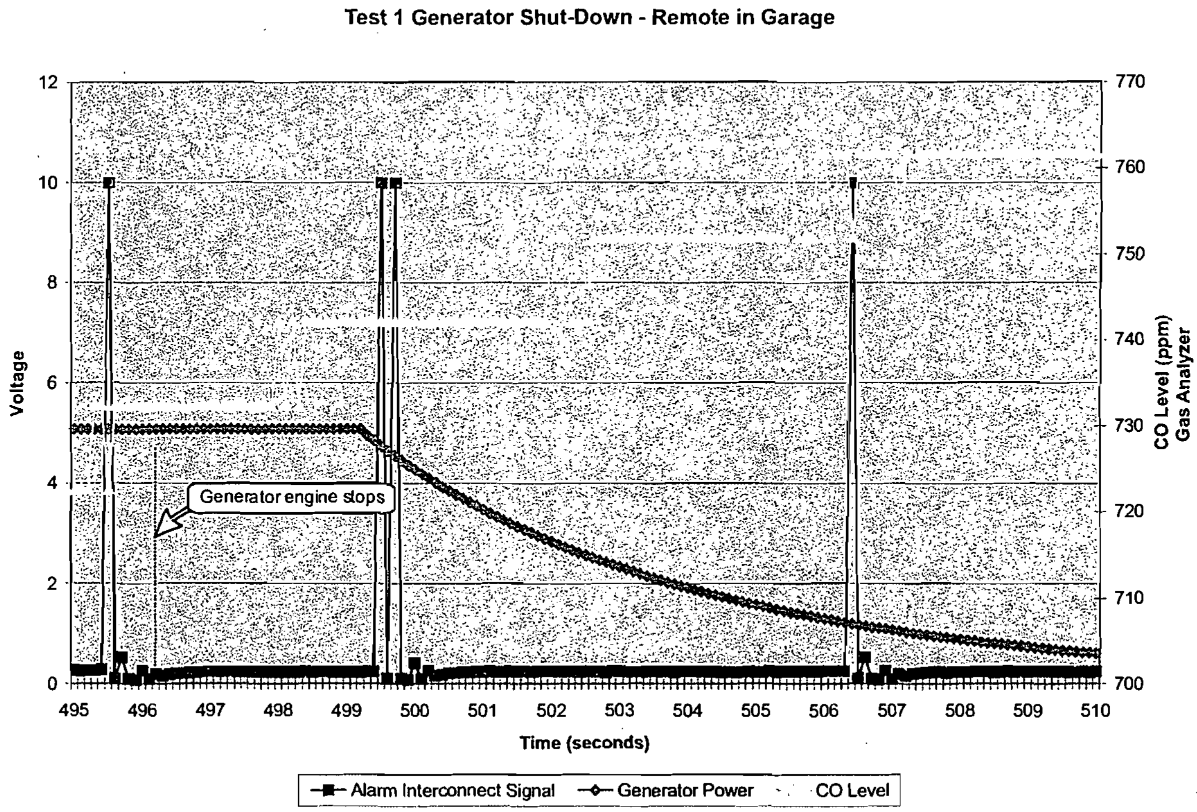



Figure 17. Remote CO detection/shut off unit in the garage disabling the generator

In the second test, the CO detection unit and CO gas analyzer were moved to the hallway, adjacent to the garage. As shown in Figure 18, the CO detection unit and the CO gas analyzer were approximately 4 feet from the door leading from the garage to the hallway. The door was ajar approximately 3/8 inch to allow an extension cord from the generator to be connected to a refrigerator in the kitchen. The door from the hallway to the living area was closed with the extension cord to the refrigerator routed under the door air gap, which was approximately 1 inch high. The load on the generator varied from near 0 amps to 2 amps, depending on whether the refrigerator's compressor was operating (which amounted to approximately 4.5% of its rated load capacity). The sampling rate of the data acquisition system was set at 1 second.

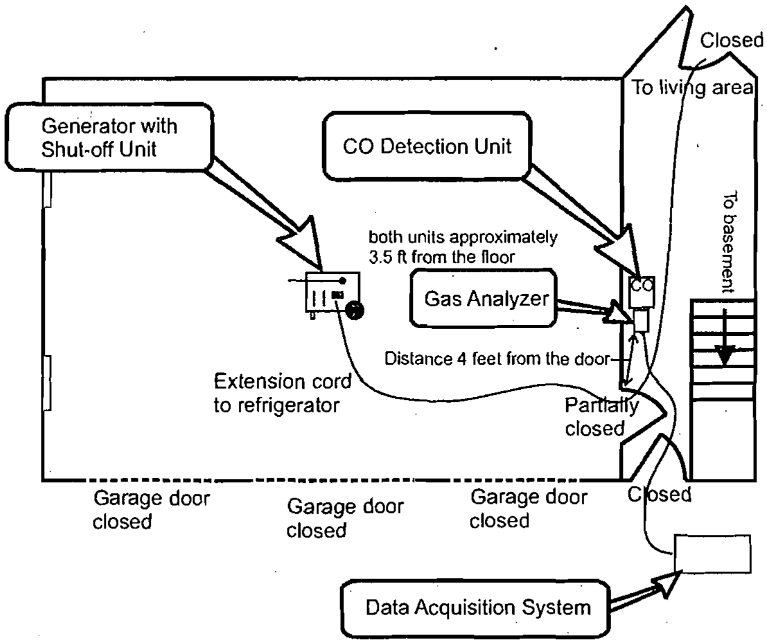



Figure 18. Test 2 set-up with remote CO detection/shut off unit in the hallway

The start button on the CO detection unit was depressed, which enabled starting of the generator. The generator was pull-started successfully. After about 17 minutes, the gas analyzer measured approximately 532 ppm in the hallway. At this time, the CO detection unit began to alarm, which caused the unit to transmit a signal to the receiver unit. The receiver unit received the signal and the generator stalled and shut off, as shown in Figure 19. In examining Figure 19, the graph makes it appear as though the generator began to shut off before the CO detection unit triggered the transmitter. This was because the digitizing system sampling rate of 1 second was not frequent enough to capture the first pulse signal from the CO detection unit. The CO detection unit's LED indicated 520 ppm when the generator was shut off.

The garage and exterior doors were opened and CO levels were allowed to drop to near zero before the operator re-entered the structure. The gas analyzer was zeroed before the next test.

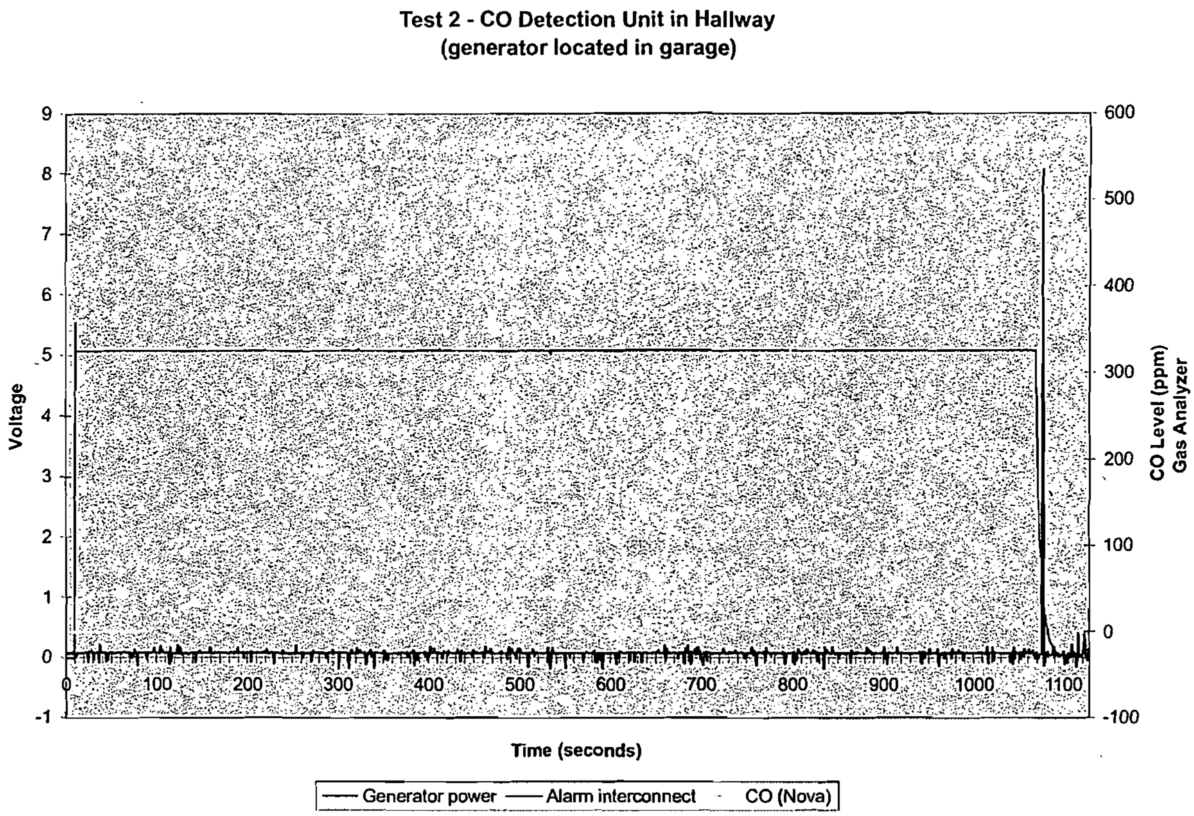



Figure 19. Remote CO detection/shut off unit in the hallway disabling the generator

In the third test, the CO detection unit and CO gas analyzer were moved to the kitchen, adjacent to the hallway to the garage. The door leading from the garage to the hallway was opened 3/8 inch to allow the extension cord from the generator to be connected to the refrigerator. The door leading from the hallway to the kitchen was opened fully. Figure 20 shows the setup for the testing.

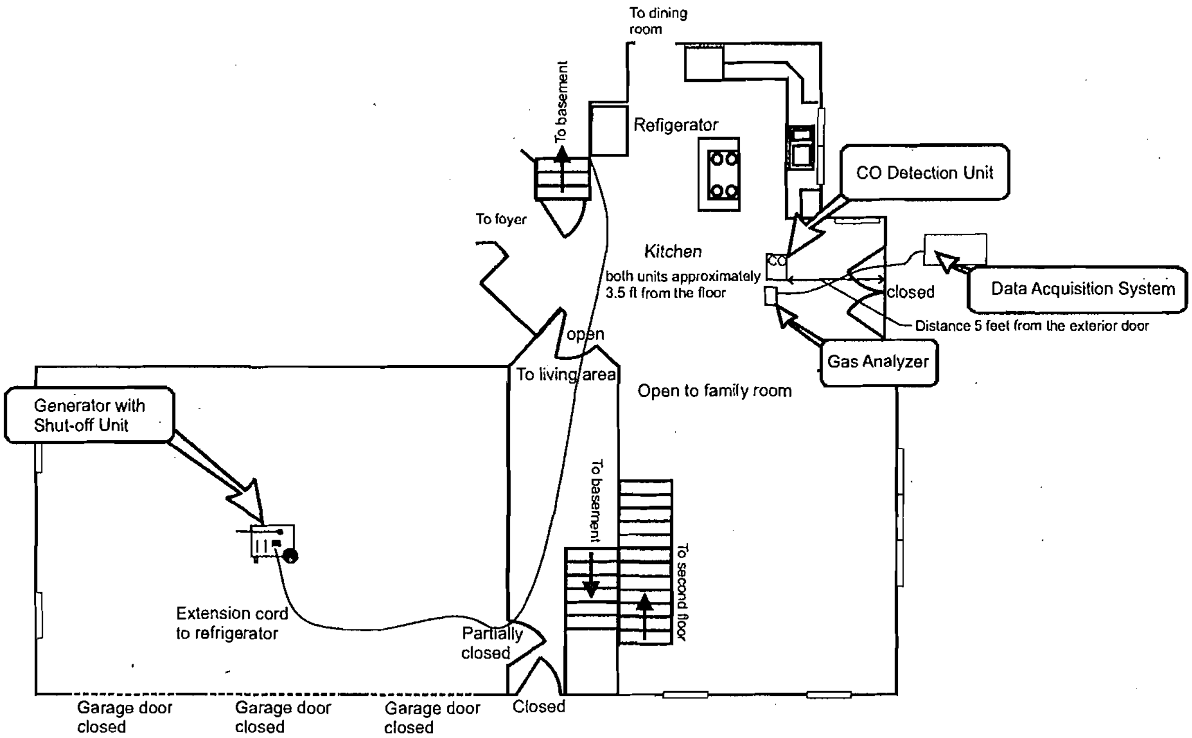



Figure 20. Test 3 set-up with remote CO detection/shut off unit in the kitchen

The start button on the CO detection unit was pressed, which enabled starting of the generator. The generator was pull-started successfully. After almost 1 hour of generator operation, the CO gas analyzer measured 90 ppm in the kitchen. Note that the CO levels in the kitchen did not reach the threshold level for the alarm to activate. To test the remote manual shut off of the generator, the test button was pressed on the CO detection unit, causing it to transmit a shut off signal. The receiver unit received the signal, causing the generator to shut off as shown in Figure 21. The LED display on the CO alarm displayed 82 ppm when the generator had shut off. The remote manual shut off of the generator allowed the tester to stop the generator without entering the garage which, based on earlier testing, most likely contained elevated levels of CO. In the first test, the CO levels in the garage measured over 700 ppm in 8 minutes. For this test, the generator was operating for almost 60 minutes before being shut off. The actual CO level in the garage was not measured.

As demonstrated in test 3, the remote shut off device could be very beneficial in that it could allow the user to shut the generator off remotely (without having the user enter the area near the generator, which may contain high levels of CO).

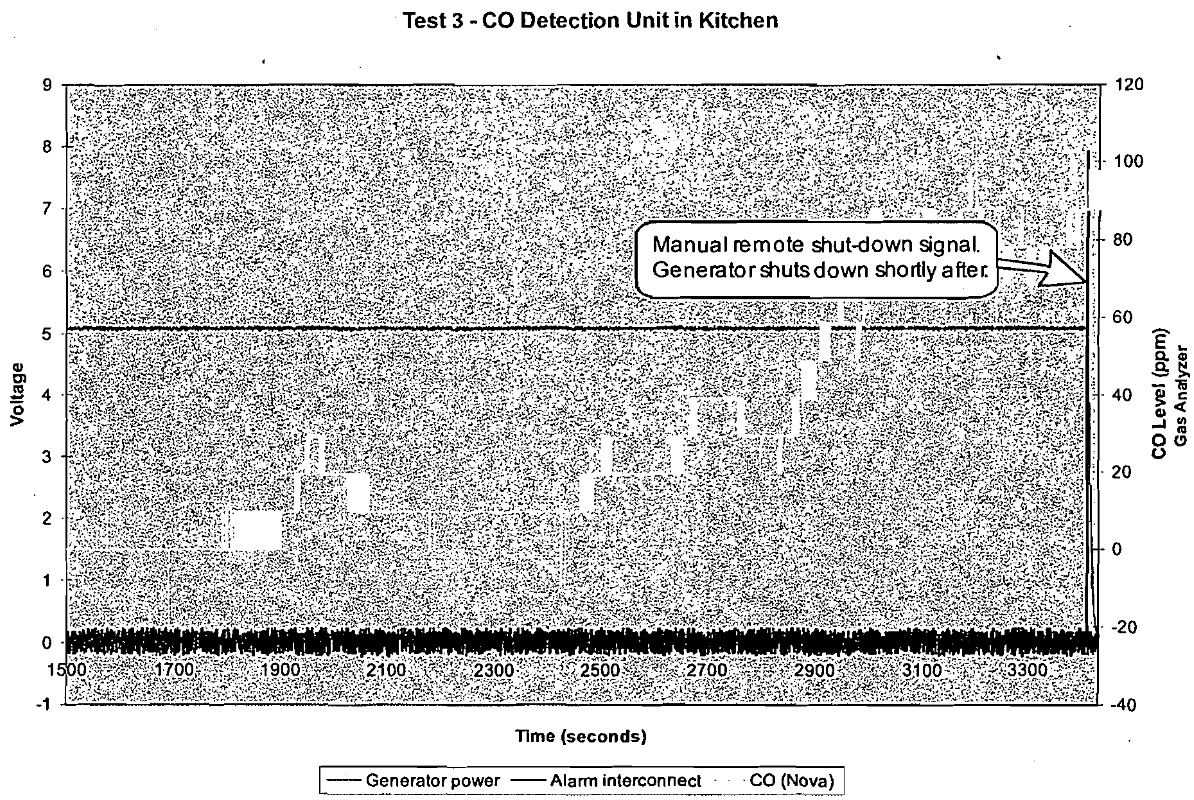



Figure 21. Remote manual shut off of the generator from the kitchen

## 4.0 Observations/Improvements

The demonstration of the experimental CO detection/shut off system showed that it is possible to incorporate an auto shut off system on a generator. The design of the experimental unit was based primarily on functionality and, therefore, was not optimized for considerations such as cost, complexity, size, usability, and reliability. After building and testing the system, staff concluded that there are features and technological improvements that could be incorporated in the CO detection and shut off system that would increase the reliability, reduce the number of components, and simplify the system.

### 4.1 Power

The demonstration system tested used a rechargeable battery to power the receiver unit before it received AC power from the generator. The system allowed the user to plug the AC/DC charger adapter into a regular household receptacle to charge the battery until needed. When needed, the user would unplug the AC/DC charger from the household receptacle and plug it into the generator's 120 VAC receptacle as shown in Figure 22. This setup allowed the battery to be fully charged at all times so that the wireless circuit would always be energized, regardless of the ON/OFF status of the CO detection unit.

A much simpler method, which could significantly reduce both the size and cost of the receiver unit on the generator, would be to use a 9-volt battery to power a receiver unit equipped with an ON/OFF power switch. The 9-volt battery would be used to power the receiver unit until the generator started. The usage life of the battery would be similar to its shelf life because of the short duration of the usage period just prior to generator start-up. Typically, an alkaline battery can have a 5-year shelf life, which may vary with extremes in temperature.

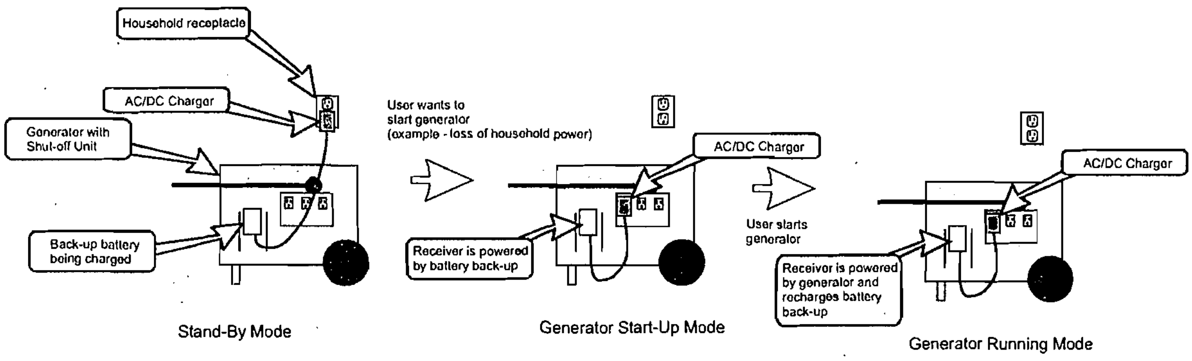



Figure 22. Powering the receiver unit

4.2 Relays

The demonstration system had six standard relays available and an additional high current relay. The six relays were programmed and controlled by the wireless circuitry. Each relay could be programmed separately. The relays could be programmed to be momentary, latched, validity**, 30-second timed, 1-minute timed, 5-minute timed, 20-minute timed, or strobed (repeated ON/OFF). Each relay could be used normally open (N.O.) or normally closed (N.C.) and was rated for 3 amps at 12 VDC. The shut off system used only two of the six relays on the circuit board. The two relays were used to control the high current relay, which was rated at 7 amps at 30 VDC or 10 amps at 125 VAC.

The number of relays needed can be reduced, and it is possible the high current relay could be eliminated. The six relay circuit board could also be reduced to one or two relays depending on the programming capabilities of the relay circuit. Reducing the number of relays would also drastically reduce the size and cost of the receiver unit.

4.3 CO Detection Unit

A residential CO alarm was integrated with a wireless transmitter. The CO alarm used AC power with battery back-up. In the testing, only the battery back-up power source was used. Since the alarm was originally designed for household plug-in as the primary power, the alarm had an LED display, which required a significant amount of power. Most battery-only powered CO alarms use an LCD display to help minimize current usage.

** Only ON when pressed and OFF when released.

4.4 Supervised System

The demonstration system utilized an unsupervised wireless system. The shut off unit on the generator and the remote CO detection unit did not incorporate an additional check for communication integrity. The disadvantage of such a system is that it would allow a user to disable the CO detection unit after starting a generator, thus leaving occupants unprotected in the event of a CO build-up.

A supervised system would allow each of the units, CO detection and shut off units, to monitor each other. The CO detection and shut off units would each have a transmitter and receiver, or a transceiver. If the shut off unit on the generator did not receive a periodic check signal from the CO detection unit, the shut off unit would disable the generator. If the CO detection unit did not receive a periodic check signal from the shut off unit, the CO detection unit would sound an alarm, indicating that it was out of range or the shut off unit had malfunctioned.

4.5 Wireless Range

The maximum range tested for the demonstration unit was approximately 50 feet through one wall or door. The minimum required reliable wireless range between the CO detection unit and generator would need to be determined to ensure that the CO detection unit and generator work as intended for consumers.

4.6 Feed-Back Indicators

The demonstration unit did not contain any feed-back indicators to indicate that the system was operating correctly. Indicator lights on the shut off unit would allow the user to know the system status.

4.7 Self-Check

The demonstration unit did not conduct a self-check of the circuitry. Similar to a supervised system for wireless communication, the self-check would determine that the remainder of the circuitry in the CO detection and shut off units was functioning.

*4.7.1 CO Detection Unit*

Self-check the CO sensor sensitivity

A periodic check of the CO sensor sensitivity to determine if the sensor has become more or less sensitive than manufacturer specifications would help prevent the CO alarm from nuisance alarming or not alarming when elevated levels are present.

Low battery check

A low battery check in the CO alarm unit would allow the user to change the battery before the system becomes nonfunctional.

Transceiver circuitry is functioning

A self-check of the transceiver circuitry would determine if the circuitry is functioning correctly.

*4.7.2 Shut Off Unit*

Self-check the relay circuitry

A self-check of the relay circuitry would determine if the circuitry is functioning correctly.

Low battery check

A low battery check in the receiver unit would allow the user to change the battery before the system becomes nonfunctional.

Transceiver circuitry is functioning

A self-check of the transceiver circuitry would determine if the circuitry is functioning correctly.

Continuity with the manual ON/OFF switch

A continuity check of the manual ON/OFF switch would determine if the receiver unit is connected to the generator and has not been disabled or bypassed.

4.8 Cost

Off-the-shelf components used in the demonstration included an AC-powered CO alarm with battery back-up, which retails for approximately $52. The CO alarm cost would be lower if it was only battery powered and contained an LCD instead of an LED display. The off-the-shelf wireless transmitter and receiver system cost approximately $100 (retail). The system contained more features than were actually required in the demonstration unit and more features than would be required in a production unit. For example, the unit was programmable, which was a useful feature for prototyping but unnecessary for production units. Additionally, although the demonstration unit contained six relays, only two were used in the system. This number could probably be further reduced to one relay with careful circuitry design and programming. The high current relay used in these tests cost approximately $12 (retail), which could have been omitted in the design. For the circuitry and the other associated hardware discussed above, the engineering staff estimates that a production unit could add an additional $100 to the cost of a portable generator. The average cost of a retail CO alarm is approximately $30 and the wireless circuitry would be an additional $50 to $70. The additional cost would depend on many factors, such as the manufacturer's approach and previous experience in using wireless technology, technique for interfacing the shut-off circuitry with the generator, and type of CO alarm. In addition, there could be additional costs in producing a final product that makes the system reliable, consumer friendly, and other factors that were not examined in this demonstration.

## 5.0 Summary

In recent years, the proliferation and increased availability of portable generators at the consumer level have resulted in an increase in the number of carbon monoxide (CO) related deaths. To help mitigate the CO hazards associated with the use of portable generators, the CPSC staff successfully demonstrated a concept to incorporate an auto shut off device on a portable gasoline-fueled engine generator that activates when elevated CO levels are detected in the home. A method of monitoring CO levels at a single location away from the generator was explored. If elevated CO levels are detected in the home, an auto shut off device can disable the generator.

A demonstration system was designed and built to evaluate the concept of shutting off a generator from a remote location when elevated levels of CO are detected. For the demonstration system, a wireless transmitter was incorporated into a CO alarm that was used as the initiating device to signal a shut off of the generator. A wireless receiver and relays were used to shut off the generator.

Several tests were conducted to determine the functionality of the CO detection and shut off system. Testing was conducted using the test button on the CO detection unit with the receiver unit mounted on the generator. Several tests were conducted to allow the CO detection unit to detect elevated levels of CO and shut off the generator remotely. In all the tests, the generator shut off when the CO detection unit transmitted a shut off signal. The CPSC staff viewed this program as a successful demonstration of the CO detection/automatic generator shut off concept.

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.

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APPENDIX A

Standard Operating Procedures
for Assuring Minimum Carbon Monoxide Exposure During Demonstration of
a Remote Carbon Monoxide Detection Shut Off Device
for a Portable Generator

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# Standard Operating Procedures

## for Assuring Minimum Carbon Monoxide Exposure During Demonstration of a Remote Carbon Monoxide Detection Shut Off Device for a Portable Generator


Prepared by Arthur S. Lee

Electrical Engineer

Division of Electrical Engineering

U.S. Consumer Product Safety Commission


August 2005

*Version 2*

1.0 PURPOSE:

The purpose of this document is to specify appropriate procedures and safeguards for test personnel to follow to protect them from exposure to potentially-harmful concentrations of carbon monoxide during testing of a prototype remote CO detection/ automatic shut off system installed on a portable generator running indoors in an actual residence. The nature of the testing is to intentionally reproduce an inappropriate (albeit foreseeable) application of a portable gasoline-fueled electric generator (operating it indoors) to evaluate the effectiveness of the prototype system.

2.0 DEFINITIONS:

For purposes of this document, the following definitions apply:

Standard Operating Procedures

The recognized, acceptable criteria which serve as support for methods or manners of fulfilling a function or functions.

CO

Carbon Monoxide. The CO in this testing will be one of the components of the exhaust gasses produced by the portable generator.

Portable Generator

The gasoline-powered engine-driven, electric generator that was outfitted with a radio-frequency (RF) receiver controlling an engine shut off device.

Remote Carbon Monoxide Detection/Shut Off Unit

The carbon monoxide detection unit that was outfitted with an RF transmitter to send a signal to the receiver unit on the generator.

PPM

Parts per million. Units representing the concentration of carbon monoxide.

Manual Remote Shut Off Device

A hand-held transmitter that can be used to shut off the generator from a location where accumulated CO is below hazardous levels.

Gas Analyzer

A portable unit that measures the level of carbon monoxide with an accuracy better than 1% of the instrument's full scale based on a 0-2000 ppm range and a response time of at most 30 seconds for a 90% step change; the unit must also be capable of remote monitoring.

3.0 SCOPE:

The testing is to demonstrate the prototype CO detection/shut off unit as incorporated with a generator by detecting CO and remotely shutting off the generator in an actual residence. The elevated levels of CO are to be generated by the portable generator in a confined space, such as a garage. The set-up and configuration of the testing to be conducted are for test purposes only and are inconsistent with correct and safe operation of a portable generator.

4.0 GUIDELINES:

Monitored CO levels

The level of CO in the test structure shall be monitored from the exterior of the test structure by two methods (residential CO alarm and a CO gas analyzer). The level of CO in the test structure shall be monitored in two areas of the test structure by residential CO alarms.

Operator(s)

The operator(s) shall be at a minimum of 20 feet from the test structure during testing. The data acquisition system shall be located a minimum of 20 feet from the exterior of the test structure. The instrumentation and operator(s) shall be upwind or adjacent to the test structure during testing. DO NOT TEST if the instrumentation and operator(s) are downwind of the test structure.

Reentry

The operator(s) shall reenter the test structure only when the CO concentration readings from both monitors are below 5 ppm. The operator(s) may enter CO monitor areas for less than 15 seconds if the CO levels are below 95 ppm. This 15-second period for concentrations below 95 ppm is within the OSHA PEL, NIOSH REL, and AGGIH TLV exposure limits for CO, as defined below.

OSHA PEL

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for carbon monoxide is 50 parts per million (ppm) parts of air (55 milligrams per cubic meter (mg/m(3))) as an 8-hour time-weighted average (TWA) concentration [29 CFR Table Z-1].

NIOSH REL

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) for carbon monoxide of 35 ppm (40 mg/m(3)) as an 8-hour TWA and 200 ppm (229 mg/m(3)) as a ceiling [NIOSH 1992].

ACGIH TLV

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned carbon monoxide a threshold limit value (TLV) of 25 ppm (29 mg/m(3)) as a TWA for a normal 8-hour workday and a 40-hour workweek [ACGIH 1994, p. 15].

Remote Shut Off

The generator shall be capable of being remotely shut off by two methods. One method must be a hand-held transmitter worn by the operator(s).

Effects of Carbon Monoxide

The operator(s) shall be familiar with the symptoms and effects of CO on a person. Signs and symptoms of acute exposure to carbon monoxide may include headache, flushing, nausea, vertigo, weakness, irritability, unconsciousness, and in persons with pre-existing heart disease and atherosclerosis, chest pain and leg pain. (U.S. Department of Labor, Occupational Safety & Health Administration)

Generator

The gas tank will be filled with a maximum of ½ gallon of gas, limiting the run time to approximately 1 hour (7 gallons for 14 hours of operation)

Test Structure

All doors to the test structure not visible by the operator(s) shall be locked to prevent persons from entering the test structure. The operator(s) shall carry keys to unlock any of the doors on the test structure.

## 5.0 PROCEDURES:

### 5.1 Initial Verification of Hardware Operation

The operator(s) shall verify that the test instrumentation and prototype test units are operational. The gas analyzer shall not have a certification older than 5 years. The wireless transmission of the shut off signal from the CO detection unit to the generator shall be tested by using the test button on the CO detection unit. The manual handheld transmitter for generator shut off shall be tested prior to any testing.

### 5.2 Location of the CO source (generator)

The portable generator shall be located in a test structure that allows easy ventilation of the test room, such as a garage. The test room or garage shall be equipped with remote ventilation, such as wireless garage door openers and fan(s).

### 5.3 Location of the CO detection units

The CO detection unit shall be located in areas of the test structure that provide accurate monitoring of CO levels in areas where operator(s) ingress and egress would result in potential exposures.

### 5.4 Pre-Testing Safety Checklist

a. Gas analyzer reading of CO level in the structure is below 5 ppm
b. CO detection unit reading is zero
c. Generator gasoline tank filled with maximum of ½ gallon of gasoline
d. Instrumentation and data acquisition ready
**e. Verify no person in the test structure**
f. Zero gas analyzer before each test

### 5.5 Post Testing Safety Checklist

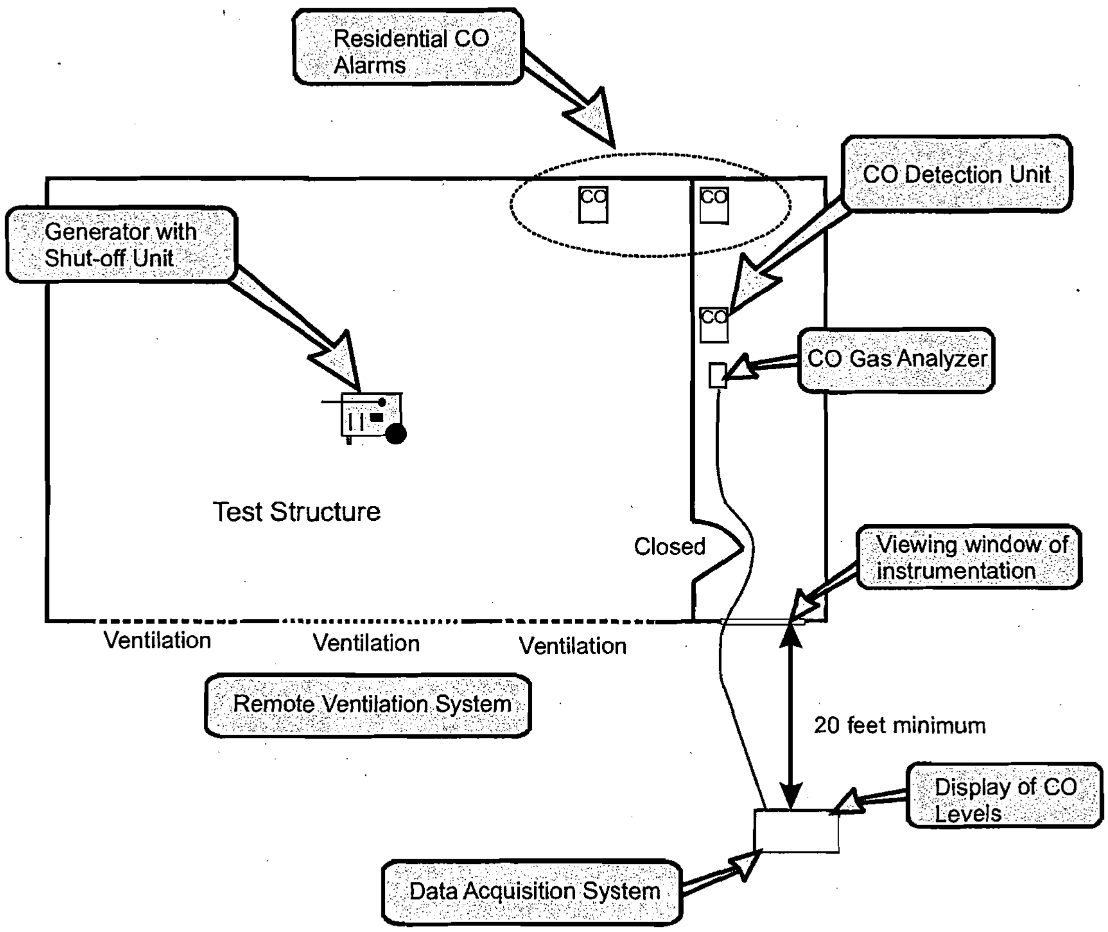
a. Generator has shut off
b. Stop data acquisition
c. Ventilate the test structure remotely
d. Monitor CO levels in the test structure

## 6.0 INSTRUMENTATION AND EQUIPMENT SET-UP:

The following is a list of instrumentations to be used in the testing:

a. Residential Carbon Monoxide Alarm (AC powered with 9-volt battery back-up)
b. NOVA Gas Analysis Equipment (Model 310WP)
c. Data Translation (Model DT9834)
d. Dell Laptop Computer (Model 5150)
e. Fluke Current Probe (Model 80i-110s)
f. Street Smart Technologies Wireless Automator (Model WA6R)
g. Portable Generator (5250 watt)

The following diagram is an illustration of the test set-up for testing the CO detection/shut off system and the portable generator.



## 7.0 EMERGENCY PROTOCOL:

Intervention for CO Poisoning

1. At first signs of CO poisoning symptoms, shut off the generator
2. Go or move victim to a well-ventilated area
3. Dial 911

# TAB T

**Examples of manufacturers' recommended safe operating clearances for generators**

**From owner's manual dated January 2004:**

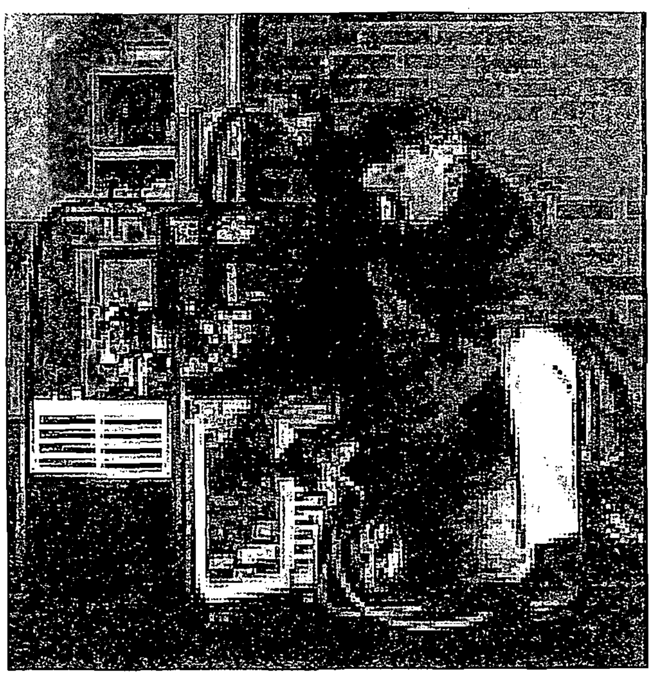
**⚠ DANGER**

**Running generator gives off carbon monoxide, an odorless, colorless, poison gas.**
**Breathing carbon monoxide will cause nausea, fainting or death.**

- Operate generator ONLY outdoors.
- Keep at least 2 feet of clearance on all sides of generator for adequate ventilation.
- DO NOT operate generator inside any building or enclosure, including the generator compartment of a recreational vehicle (RV).

**One generator manufacturer's website says the following:**
Never operate an internal combustion engine inside your home, basement, garage or any other enclosed area. The generator needs a minimum of 3 to 4 feet of spacing on all sides (including the top). A generator needs an unlimited supply of fresh air for proper cooling during operation. Properly locate the generator outdoors away from doors and windows. An open door or window will allow dangerous exhaust fumes to enter the building. Since combustion engines create carbon monoxide, which can be lethal, good ventilation is critical. Keep the generator dry and always operate it on a level surface. Never add fuel to your generator when it is running and always store additional fuel in approved Gasoline containers.

**Picture from one generator manufacturer's website showing set-up of generator outside next to slightly open sliding glass door:**



**Page from generator manufacturer's instruction manual recommending use of less than 15 foot long extension cords**

## CORD SETS AND RECEPTACLES

**⚠ CAUTION**

**Receptacles may be marked with rating value greater than generator output capacity.**

- NEVER attempt to power a device requiring more amperage than generator or receptacle can supply.
- DO NOT overload the generator. See "Don't Overload Generator".

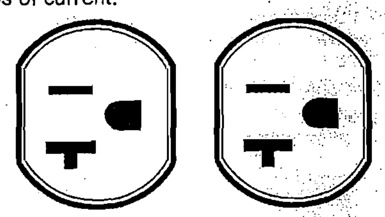
Use only high quality, well-insulated, extension cords with the generator's 120 Volt electrical receptacles.

Check the ratings of all extension cords before you use them. Extension cord sets used should be rated for 125 Volt AC loads at 20 Amps or greater for most electrical devices. Some devices, however, may not require this type of extension cord. Check the owner's manuals of those devices for the manufacturer's recommendations.

Keep extension cords as short as possible, preferably less than 15 feet long, to prevent voltage drop and possible overheating of wires.

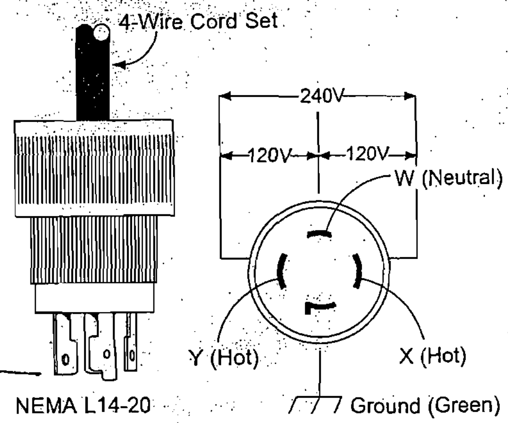
### 120 Volt AC, 20 Amp Duplex Receptacle

Each receptacle is protected against overload by a single 15 Amp push-to-reset circuit breaker. Use each receptacle to operate 120 Volt AC, single phase 60 Hz electrical loads requiring up to 2,400 watts (2.4 kW) at 20 Amps of current.



### 120/240 Volt AC, 20 Amp Receptacle

This is a full capacity receptacle; it can supply the generator's full rated output from this sole outlet. The outlet is protected by two 15 Amp push–to–reset circuit breakers.




A NEMA L14-20 plug is used with this 240 Volt receptacle. Connect a suitable 4-wire cord set to the plug and to the desired load. The cord set should be rated for 250 Volt AC loads at 20 Amps (or greater).

## COLD WEATHER OPERATION

Under certain weather conditions (temperatures below 40°F [4°C] combined with high humidity), your Craftsman generator may experience icing of the carburetor and/or the crankcase breather system. To reduce this problem, you need to perform the following:

1. Make sure generator has clean, fresh fuel.
2. Open fuel valve (turn valve to open position).
3. Use SAE 5W-30 oil (synthetic preferred, see page 7).
4. Check oil level daily or after every eight (8) hours of operation.
5. Maintain the generator following the "Maintenance Schedule" on page 14.
6. Shelter unit from elements.

# TAB U

FEMA

# Important Tips to Ensure Safety When Using Generators

Release Date: March 18, 2006
Release Number: 1603-406

» More Information on Louisiana Hurricane Rita
» More Information on Louisiana Hurricane Katrina

BATON ROUGE, La. -- Federal and state disaster officials remind applicants to practice safety measures when using portable generators. Generators are useful when temporary or remote electric power is needed but can also be extremely hazardous and even life threatening. The primary hazards when using a generator are carbon monoxide (CO) poisoning from the toxic engine exhaust, electric shock or electrocution and fire.

The Occupational Safety and Health Administration (OSHA) offers the following cautions on the use of gas-powered generators and other tools:

**Shock and Electrocution**

- Never attach a generator directly to the electrical system of structure (home, office, trailer, etc.) unless a qualified electrician has properly installed the generator with a transfer switch.
- Always plug electrical appliances directly into the generator using the manufacturer's supplied cords or extension cords that are grounded (3-pronged). Inspect the cord to make sure they are fully intact and not damaged. Never use frayed or damaged extension cords.
- Keep a generator dry; do not use it in the rain or in wet conditions. If needed, protect a generator with a canopy.

**Carbon Monoxide Poisoning**

- Never use a generator indoors or in enclosed spaces such as garages, crawl spaces, and basements.
- Make sure a generator has three to four feet of clear space on all sides and above it to ensure adequate ventilation.
- Be cautious when using a generator outdoors to ensure it is not placed near doors, windows, and vents could allow CO to enter and build up in occupied spaces.
- If you or others show symptoms of CO poisoning□dizziness, headaches, nausea, tiredness□get to fresh air immediately and seek medical attention. Do no re-enter the area until it is determined to be safe by trained and properly equipped personnel.

**Fire Hazards**

- Generators become hot while running and remain hot for long periods after they are stopped. Generator fuels (gasoline, kerosene, etc.) can ignite when spilled on hot engine parts.
- Before refueling, shut down the generator and allow it to cool.
- Gasoline and other generator fuels should be stored and transported in approved containers that are properly designed and marked for their contents, and vented.
- Keep fuel containers away from flame producing and heat generating devices (such as the generator itself, water heaters, cigarettes, lighters, and matches). Do not smoke around fuel containers.

## Noise and Vibration Hazards

- Generator engines vibrate and create noise.
- Excessive noise and vibration could cause hearing loss and fatigue that may affect job performance.
- Keep portable generators as far away as possible from work areas and gathering spaces.
- Wear hearing protection if this is not possible.

*FEMA prepares the nation for all hazards and manages federal response and recovery efforts following any national incident. FEMA also initiates mitigation activities, trains first responders, works with state and local emergency managers, and manages the National Flood Insurance Program.*

# OSHA QUICK CARD™

**Protect Yourself**

## Carbon Monoxide Poisoning

Carbon monoxide (CO) is a colorless, odorless, toxic gas which interferes with the oxygen-carrying capacity of blood. CO is non-irritating and can overcome persons without warning. Many people die from CO poisoning, usually while using gasoline powered tools and generators in buildings or semi-enclosed spaces without adequate ventilation.

**Effects of Carbon Monoxide Poisoning**

- Severe carbon monoxide poisoning causes neurological damage, illness, coma and death.

**Symptoms of CO exposure**

- Headaches, dizziness and drowsiness.
- Nausea, vomiting, tightness across the chest.

**Some Sources of Exposure**

- Portable generators/generators in buildings.
- Concrete cutting saws, compressors.
- Power trowels, floor buffers, space heaters.
- Welding, gasoline powered pumps.

**Preventing CO Exposure**

- Never use a generator indoors or in enclosed or partially enclosed spaces such as garages, crawl spaces, and basements. Opening windows and doors in an enclosed space may prevent CO buildup.
- Make sure the generator has 3-4 feet of clear space on all sides and above it to ensure adequate ventilation.
- Do not use a generator outdoors if placed near doors, windows or vents which could allow CO to enter and build up in occupied spaces.
- When using space heaters and stoves ensure that they are in good working order to reduce CO buildup, and never use in enclosed spaces or indoors.
- Consider using tools powered by electricity or compressed air, if available.
- If you experience symptoms of CO poisoning get to fresh air right away and seek immediate medical attention.

**For more complete information:**

OSHA Occupational Safety and Health Administration
U.S. Department of Labor
www.osha.gov (800) 321-OSHA

OSHA 3267-09N-05

**U.S. Environmental Protection Agency**

Hurricane Response 2005

Contact Us | Print Version Search: GO

EPA Home > Hurricane Response 2005 > Potential Environmental Health Hazards When Returning to Homes and Businesses



# Potential Environmental Health Hazards When Returning to Homes and Businesses



Cleanup activities related to returning to homes and businesses after Hurricane Katrina can pose significant health and environmental challenges. People may be exposed to potentially life-threatening hazards posed by leaking natural gas lines, and carbon monoxide poisoning from using un-vented fuel-burning equipment indoors. During a flood cleanup, failure to remove contaminated materials and to reduce moisture and humidity may present serious long-term health risks from micro-organisms, such as bacteria and mold.

When citizens are authorized by local authorities to return to their homes and businesses, federal authorities urge people to take the following precautions:

**General Cautions when Re-entering Hurricane-Damaged Homes and Buildings**

EPA urges the public to be on the alert for leaking containers and reactive household chemicals, like caustic drain cleaners and chlorine bleach, and take the following necessary precautions to prevent injury or further damage:

- Keep children and pets away from leaking or spilled chemicals.
- Do not combine chemicals from leaking or damaged containers as this may produce dangerous or violent reactions.
- Do not dump chemicals down drains, storm sewers or toilets.
- Do not attempt to burn household chemicals.
- Clearly mark and set aside unbroken containers until they can be properly disposed of
- Leave damaged or unlabeled chemical containers undisturbed whenever possible.

Individuals should exercise caution when disturbing building materials to prevent physical injury or other health effects. Building materials may contain hazardous materials such as asbestos that when carried by the air can be breathed in and cause adverse health effects. If it is suspected that asbestos containing materials may be present, they should not be disturbed. Asbestos containing materials include the following:

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- boiler/pipe insulation
- fireproofing
- floor tiles
- asbestos roofing
- transite boards used in laboratory tabletops and in acoustics in auditoriums, music rooms and phone booths

Federal, state and local personnel are being deployed to the hurricane-affected areas to establish debris-management programs, including household hazardous waste collection and disposal programs. These efforts may take days or weeks to come to all communities. In the meantime, EPA urges the public to exercise caution and report concerns to local environmental, health and waste disposal authorities.

top of page

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**Be Aware of Possible Combustible or Explosive Gases** - Many natural gas and other fuel lines were broken during Hurricane Katrina and highly explosive gas vapors may still be present in many buildings. In addition, methane and other explosive gases may accumulate from decaying materials.

top of page

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**Open all windows when entering a building. If you smell gas or hear the sound of escaping gas:**

- Don't smoke, light matches, operate electrical switches, use either cell or conventional telephones, or create any other source of ignition.
- Leave the building immediately; leaving the door open and any windows that may already be open.
- Notify emergency authorities. Don't return to the building until you are told by authorities that it is safe to do so.

top of page

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**Avoid Carbon Monoxide Poisoning** - Carbon monoxide (CO) is a colorless, odorless gas that is produced when any fuel is burned and that can kill you at high levels.

- Do not use fuel-burning devices such as gasoline-powered generators, gasoline-powered pressure washers, camp stoves and lanterns, or charcoal grills in homes, garages, or any other confined space such as attics or crawl spaces, or within 10 ft. of windows, doors *or other air intakes. Opening doors* and windows or using fans will not prevent CO buildup in the home. Have vents and chimneys checked to assure that debris does not block or impede the exhaust from water heaters and gas furnaces.
- If you start to feel sick, dizzy or weak while using a generator, get to fresh air right away. The CO from generators can readily lead to full incapacitation

# TAB V

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

**Memorandum**

Date: November 29, 2005

TO : Janet Buyer
Project Manager, Portable Generators
Division of Combustion and Fire Sciences,
Directorate for Engineering Sciences

THROUGH: Hugh McLaurin
Associate Executive Director, ES

Margaret L. Neily
Division Director, ESFS

FROM : Don Switzer
Chemical Engineer, ESFS

SUBJECT : Potential Benefits of a Private Sector Consortium of Manufacturers to Develop a Technical Solution to Address the CO Poisoning Hazard Posed by Engine-Driven Generators

REF: *Antitrust Guidelines for Collaborations Among Competitors*, Issued by the Federal Trade Commission and the U.S. Department of Justice, April 2000

Manufacturers have, in the past, formed joint product development consortiums to attempt to develop sophisticated technical solutions to complex product safety hazards identified by the U.S. Consumer Product Safety Commission (CPSC) staff.* The Department of Justice recognizes that under certain conditions the public can be well-served by allowing manufacturers to form collaborations to achieve certain goals. The referenced document, *Antitrust Guidelines for Collaboration Among Competitors*, explains how the Department of Justice analyzes certain antitrust issues raised by collaborations among competitors. The Guidelines state, "In order to compete in modern markets, competitors sometimes need to collaborate. Competitive forces are driving firms toward complex collaborations to achieve goals such as expanding into foreign markets, funding expensive innovation efforts, and lowering production and other costs." Furthermore, "Such collaborations often are not only benign but procompetitive."

Collaboration among market participants may benefit the participants by providing resources beyond the reach of individual competitors to develop innovative designs to address a particular hazard. Collaboration may allow member companies to better use existing research and development assets, or may provide incentives for them to make product enhancing investments that would not occur absent the collaboration. The consumer may also benefit in that

* This memorandum was prepared by CPSC staff and has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

collaboration could allow accelerated product development, resulting in improved products reaching market more quickly.

The efforts of the water heater industry to address the hazards of ignition of flammable vapors are a case in point of the successful use of a consortium to develop a technological solution to a serious safety problem. In March 1995, State Industries, American Water Heater Company, Bradford White Corporation, GSW Water Heating Company, and Rheem Manufacturing Company received permission from the U.S. Department of Justice to form the Water Heater Industry Joint Product Development Consortium. The water heater consortium allowed member companies to pool staff and financial resources to facilitate development of flammable vapor ignition-resistant (FVIR) water heaters.

CPSC staff believes that by working together, the water heater consortium members were able to allocate significantly more resources to solving the problem than would have been available to individual members. They were able to (and are continuing to) examine the performance of multiple possible technical solutions to the vapor ignition problem. Each company assigned representatives to the consortium team whose primary jobs were to develop the needed technologies to solve the problem. By using this team approach, multiple tasks were undertaken at the same time, resulting in more efficient resource allocation, and the elimination of duplicate efforts that would have resulted if the companies were not working together.

Working together both accelerated the development process, and reduced the overall cost to the manufacturers. The benefits of scale were particularly apparent during prototype tests where the consortium was able to conduct field tests on a very substantial number of units, exposing them to a wider range of environmental conditions than could be achieved with a smaller test set. Staff also believes that, without the resource pooling, some of the manufacturers involved would have had neither the technical nor financial resources to develop FVIR technology on their own. Although water heater consortium member companies worked on a common technology, each firm was able to tailor the specific design of the common technology to their individual products and manufacturing processes.

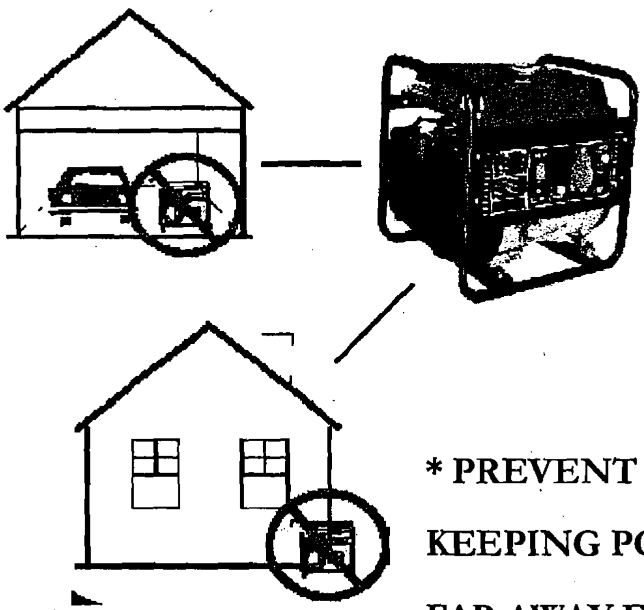
In addition to assisting in developing technologies, the water heater consortium played a pivotal role in developing the voluntary performance requirements ultimately adopted. It is natural for manufacturer members of voluntary standard committees to attempt to protect competitive advantages when developing standards. Although there were disagreements between the consortium manufacturers and non-consortium manufacturers over the specifics of the test methodology, the fact that a group of manufacturers was working together greatly reduced the disagreements that often slow voluntary standard development. Overall, the water heater consortium assisted in identifying and developing technologies and standard test methods to certify the performance of water heaters.

# TAB W

# Returning Home Safely After Katrina

Life-saving tips for homeowners recovering from the hurricane

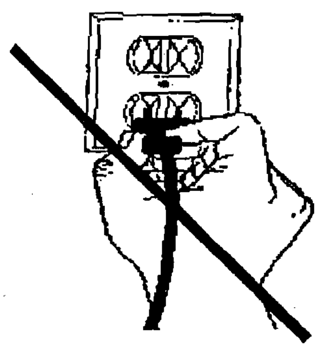
## Warning



* NEVER USE A PORTABLE GENERATOR INDOORS, INCLUDING GARAGES, BASEMENTS, CRAWLSPACES AND SHEDS. GAS GENERATORS CAN GIVE OFF DEADLY LEVELS OF CARBON MONOXIDE.

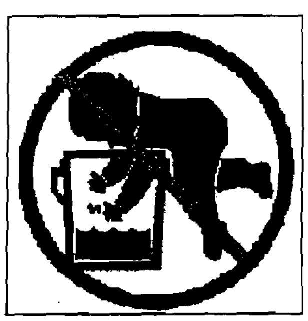
* PREVENT A POTENTIALLY FATAL INCIDENT BY KEEPING PORTABLE GENERATORS OUTDOORS AND FAR AWAY FROM OPEN DOORS, WINDOWS AND VENTS.

## Warning



* THROW AWAY THOSE ELECTRICAL AND GAS APPLIANCES THAT HAVE BEEN FLOODED AS THEY POSE ELECTRIC SHOCK AND FIRE HAZARDS. ARRANGE FOR A PROFESSIONAL OR YOUR GAS OR ELECTRIC COMPANY TO CONDUCT AN INSPECTION OF YOUR HOME.

## Warning



*WATCH CHILDREN AROUND BUCKETS, TUBS AND STANDING WATER IN AND AROUND THE HOME. EVEN SMALL AMOUNTS OF WATER CAN BE A DROWNING HAZARD.



Recommendations provided by the U.S. Consumer Product Safety Commision (CPSC).

# NEWS from CPSC

## U.S. Consumer Product Safety Commission

Office of Information and Public Affairs Washington, DC 20207

FOR IMMEDIATE RELEASE
July 8, 2005
Release #05-223

**CPSC Recall Hotline: (800) 638-2772**
CPSC Media Contact: Scott Wolfson, (301) 504-7051

## *Surviving the Aftermath of Hurricane Dennis*
## CPSC Warns of Post-Storm Hazards from Portable Generators, Candles, and Wet Appliances

WASHINGTON, D.C. – In advance of Hurricane Dennis hitting the Gulf Coast, the U.S. Consumer Product Safety Commission (CPSC) is warning residents in its path of the deadly dangers that can exist after a natural disaster sweeps through and knocks out power and causes flooding. The most serious hazard involves portable generators, which are often used to deal with the loss of electricity. Deaths tragically and frequently occur after a storm has passed, when homeowners or business owners set up a generator indoors or too close to a home or building.

CPSC strongly warns consumers to **never** use a generator indoors – including garages, basements, crawlspaces and sheds – even with ventilation. Exhaust fumes contain extremely high levels of carbon monoxide (CO) which can rapidly become deadly if inhaled. Last year, numerous deaths were reported throughout the Southeast due to CO poisoning while using generators in the aftermath of the four hurricanes that hit the region.

Consumers should only use a portable generator outdoors in a dry area away from doors, windows and vents that can allow CO to come indoors. Wait for the rain to pass before using a generator, as consumer-grade generators are not weatherproof and can pose the risk of electrocution and shock when used in wet conditions.

Additional life-saving safety tips from CPSC include:

- If using a generator, plug individual appliances into heavy duty, outdoor-rated extension cords and plug the cords into the generator.
- Check that the extension cords have a wire gauge adequate for the appliance loads and have all three prongs, including a grounding pin.
- Never store gasoline in the home or near a fuel-burning appliance, such as a natural gas water heater, where gasoline fumes could be ignited.
- Never use charcoal indoors – burning charcoal in an enclosed space can produce lethal levels of carbon monoxide.
- Make sure the batteries in your smoke alarm and carbon monoxide alarm are fresh. Test these alarms to make sure they are working.
- Do not use electrical or gas appliances that have been wet, and do not turn on damaged appliances because of the hazards of electric shock or fire. Do not use gas appliances that have been submerged because silt can make valves inoperable, leading to a gas leak or fire.
- Exercise caution when using candles. Use flashlights instead. If you must use candles, do not burn them on or near anything that can catch fire. Never leave burning candles unattended. Extinguish candles when you leave the room.

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Send the link for this page to a friend! The U.S. Consumer Product Safety Commission is charged with protecting the public from unreasonable risks of serious injury or death from more than 15,000 types of consumer products under the agency's jurisdiction. Deaths, injuries and property damage from consumer product incidents cost the nation more than $700 billion annually. The CPSC is committed to protecting consumers and families from products that pose a fire, electrical, chemical, or mechanical hazard or can injure children. The CPSC's work to ensure the safety of consumer products - such as toys, cribs, power tools, cigarette lighters, and household chemicals - contributed significantly to the 30 percent decline in the rate of deaths and injuries associated with consumer products over the past 30 years.

To report a dangerous product or a product-related injury, call CPSC's hotline at (800) 638-2772 or CPSC's teletypewriter at (800) 638-8270, or visit CPSC's web site at www.cpsc.gov/talk.html. To join a CPSC email subscription list, please go to www.cpsc.gov/cpsclist.asp. Consumers can obtain this release and recall information at CPSC's Web site at www.cpsc.gov.

# NEWS from CPSC

## U.S. Consumer Product Safety Commission

Office of Information and Public Affairs Washington, DC 20207

FOR IMMEDIATE RELEASE
September 13, 2005
Release #05-269

**CPSC Recall Hotline: (800) 638-2772**
CPSC Media Contact: Patty Davis (301) 504-7908

# CPSC Warns of New Dangers Among Gulf Coast Victims of Hurricane Katrina From Deadly CO Poisonings

### *Offers Important New Safety Tips for Residents Able to Return Home After Hurricane*

WASHINGTON, D.C. – With a sharp increase in the number of carbon monoxide related deaths among Gulf Coast residents stemming from the unsafe use of outdoor portable generators in the aftermath of Hurricane Katrina, the U.S. Consumer Product Safety Commission (CPSC) today announced a major new initiative urging hurricane victims to avoid a potentially fatal situation by never using these generators indoors.

Unofficial estimates indicate at least 11 deaths and numerous injuries have been attributed to carbon monoxide poisoning stemming from portable generators used in areas with power outages. The CPSC is coordinating with the CDC and other health and safety organizations, as well as our nation's largest home improvement and hardware retailers, to provide life-saving safety warnings to Gulf Coast residents – many of whom are expected to be first time users of generators.

"As federal, state and local officials continue their important relief mission in the aftermath of Hurricane Katrina, thousands of families are fortunately beginning the process of returning to their homes," said CPSC Chairman Hal Stratton. "So we're reminding all Gulf Coast residents that some of the biggest dangers lie in the aftermath of the hurricane, the greatest of which can be carbon monoxide poisoning."

Stratton provided hurricane survivors with these important life-saving tips:

- Never use a portable generator indoors – including garages, basements, crawlspaces and sheds. Opening doors and windows or using fans will not prevent CO buildup in the home.
- During use, keep portable generators outdoors and far away from open doors, windows and vents, which can allow CO to build up indoors.
- If you start to feel sick, dizzy or weak while using a generator, get to fresh air right away. The CO from generators can readily lead to full incapacitation and death.
- Keep generators dry and wait for the rain to pass before using a generator. Consumer-grade generators are not weatherproof and can pose the risk of electrocution and shock when used in wet conditions.
- Do not connect the generator directly into your home's electrical system through a receptacle outlet – this is an extremely dangerous practice that poses a fire hazard and an electrocution hazard to utility workers and neighbors served by the same transformer.
- If using a generator, plug individual appliances into heavy duty, outdoor-rated extension cords and plug cords into the generator.
- Check that the extension cords have a wire gauge adequate for the appliance loads and have all three prongs, including a grounding pin.
- Keep charcoal grills outside. Never use them indoors. Burning charcoal in an enclosed space can produce lethal levels of carbon monoxide poisoning.

- Check to make sure your smoke alarms and carbon monoxide alarms have batteries and are working.

**Wet Carpets and Furniture Are Dangerous to your Health**

- Discard water-damaged mattresses, wicker furniture, straw baskets and the like that have been water damaged. These cannot be recovered.
- Throw out wet room-size carpets, drapes, upholstered furniture, stuffed toys, ceiling tiles and anything that can't be picked up and cleaned by dry cleaning, steam cleaning or put in a washing machine or dryer.
- Remove and replace wet insulation.
- Microorganisms may grow in these water-damaged products and may cause allergic reactions and infections. For more information, go to http://www.cpsc.gov/CPSCPUB/PUBS/425.html

**Avoid Electrical and Gas Hazards**

- Look for signs that your appliances have gotten wet. Discard electrical or gas appliances that have been wet because they pose electric shock and fire hazards.
- Before using your appliances, have a professional or your gas or electric company evaluate your home and replace all gas control valves, circuit breakers, and fuses that have been under water.

**Dangers to Children**

- Medicines and chemicals should be thrown away. Water may have infected the integrity of the medicine. The U.S. Department of Health and Human Services offers additional safety tips. For more information, go to http://www.hhs.gov/news/broadcast/2005/CrawfordMedicationSafety.html
- Young children and water don't mix. Watch children around buckets, tubs and standing water in and around the home. Even small amounts of water can be a drowning hazard.

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# NEWS from CPSC

## U.S. Consumer Product Safety Commission

Office of Information and Public Affairs Washington, DC 20207

FOR IMMEDIATE RELEASE
August 31, 2005
Release #05-251

**CPSC Recall Hotline: (800) 638-2772**
CPSC Media Contact: Patty Davis (301) 504-7908

***Surviving the Aftermath of Hurricane Katrina***

## CPSC Warns of Deadly Post-Storm Dangers with Portable Generators, Candles and Wet Appliances

WASHINGTON, D.C. – The U.S. Consumer Product Safety Commission (CPSC) is warning residents of the Gulf Coast hit by Hurricane Katrina not to let disaster strike a second time. Deadly dangers exist in and around homes affected by the hurricane. The most serious hazard involves portable generators, which will be used in areas where the electricity has been knocked out by hurricane force winds and flooding.

CPSC strongly warns consumers to **never** use a generator indoors – including garages, basements, crawlspaces and sheds – even with ventilation. Exhaust fumes contain extremely high levels of carbon monoxide (CO) which can rapidly become deadly if inhaled. Last year, numerous deaths were reported throughout the Southeast due to CO poisoning while using generators in the aftermath of the four hurricanes that hit the region.

Consumers should only use a portable generator outdoors in a dry area away from doors, windows and vents that can allow CO to come indoors. Wait for the rain to pass before using a generator, as consumer-grade generators are not weatherproof and can pose the risk of electrocution and shock when used in wet conditions.

Additional life-saving safety tips from CPSC include:

- If using a generator, plug individual appliances into heavy duty, outdoor-rated extension cords and plug the cords into the generator.
- Check that the extension cords have a wire gauge adequate for the appliance loads and have all three prongs, including a grounding pin.
- Never store gasoline in the home or near a fuel-burning appliance, such as a natural gas water heater, where gasoline fumes could be ignited.
- Never use charcoal inside homes, tents, campers, vans, cars, trucks, garages, or mobile homes. Burning charcoal in an enclosed space can produce lethal levels of carbon monoxide.
- Make sure the batteries in your smoke alarm and carbon monoxide alarm are fresh. Test these alarms to make sure they are working.
- Do not use electrical or gas appliances that have been wet, and do not turn on damaged appliances because of the hazards of electric shock or fire. Replace all gas control valves, circuit breakers, and fuses that have been under water.
- Exercise caution when using candles. Use flashlights instead. If you must use candles, do not burn them on or near anything that can catch fire. Never leave burning candles unattended. Extinguish candles when you leave the room.
- Chain saws can be hazardous, especially if they "kick back." To help reduce this hazard, make sure that your chain saw is equipped with a low-kickback chain. Always wear shoes, gloves, and protective glasses.

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# NEWS from CPSC

## U.S. Consumer Product Safety Commission

Office of Information and Public Affairs Washington, DC 20207

FOR IMMEDIATE RELEASE
September 15, 2005
Release #05-273

**CPSC Consumer Hotline: (800) 638-2772**
CPSC Media Contact: Patty Davis: (301) 504-7601

## *Safety Tips for Hurricane Victims*
## CPSC Warns of Dangers at Home in the Aftermath of Hurricane Ophelia

WASHINGTON, D.C. – The U.S. Consumer Product Safety Commission (CPSC) warns residents in the path of Hurricane Ophelia in North Carolina and nearby coastal communities to take special precautions.

"Based on our experience with Hurricane Katrina on the Gulf Coast, people often use portable generators when their power is knocked out," said CPSC Chairman Hal Stratton. "But if you don't use them safely, you risk deadly carbon monoxide poisoning. NEVER use a generator inside the house or attached garage. Keep it a safe distance from your home. Don't take a chance."

Unofficial estimates indicate at least 11 deaths and numerous injuries have been attributed to carbon monoxide poisoning stemming from portable generators used in the aftermath of Hurricane Katrina on the Gulf Coast.

The Commission provided these important life-saving tips:

- Never use a portable generator indoors – including garages, basements, crawlspaces and sheds. Opening doors and windows or using fans will not prevent CO buildup in the home.
- During use, keep portable generators outdoors and far away from open doors, windows and vents, which can allow CO to build up indoors.
- If you start to feel sick, dizzy or weak while using a generator, get to fresh air right away. The CO from generators can readily lead to full incapacitation and death.
- Keep generators dry and wait for the rain to pass before using a generator. Consumer-grade generators are not weatherproof and can pose the risk of electrocution and shock when used in wet conditions.
- Do not connect the generator directly into your home's electrical system through a receptacle outlet – this is an extremely dangerous practice that poses a fire hazard and an electrocution hazard to utility workers and neighbors served by the same transformer.
- If using a generator, plug individual appliances into heavy duty, outdoor-rated extension cords and plug cords into the generator.
- Check that the extension cords have a wire gauge adequate for the appliance loads and have all three prongs, including a grounding pin.
- Keep charcoal grills outside. Never use them indoors. Burning charcoal in an enclosed space can produce lethal levels of carbon monoxide poisoning.
- Check to make sure your smoke alarms and carbon monoxide alarms have batteries and are working.

### Wet Carpets and Furniture Are Dangerous to your Health

- Discard water-damaged mattresses, wicker furniture, straw baskets and the like that have been water damaged. These cannot be recovered.

- Throw out wet room-size carpets, drapes, upholstered furniture, stuffed toys, ceiling tiles and anything that can't be picked up and cleaned by dry cleaning, steam cleaning or put in a washing machine or dryer.
- Remove and replace wet insulation.
- Microorganisms may grow in these water-damaged products and may cause allergic reactions and infections. For more information, go to http://www.cpsc.gov/CPSCPUB/PUBS/425.html

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- Look for signs that your appliances have gotten wet. Discard electrical or gas appliances that have been wet because they pose electric shock and fire hazards.
- Before using your appliances, have a professional or your gas or electric company evaluate your home and replace all gas control valves, circuit breakers, and fuses that have been under water.

**Dangers to Children**

- Medicines and chemicals should be thrown away. Water may have infected the integrity of the medicine. The U.S. Department of Health and Human Services offers additional safety tips. For more information, go to http://www.hhs.gov/news/broadcast/2005/CrawfordMedicationSafety.html
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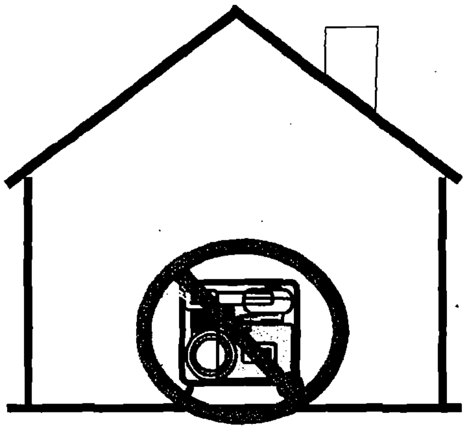
# WARNING

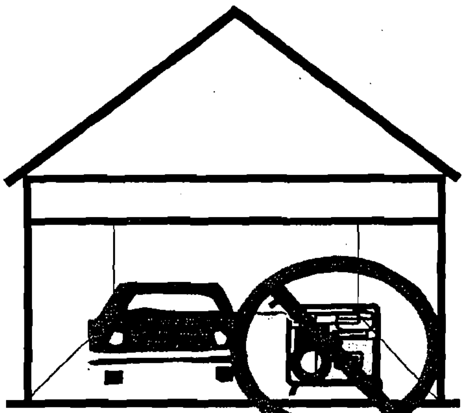
POISONOUS GAS - POISONOUS GAS - POISONOUS GAS

# CARBON MONOXIDE HAZARD

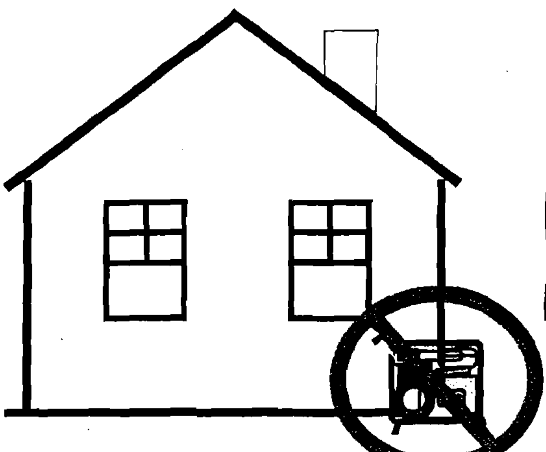
## Fumes can be harmful or fatal.
## You CANNOT see or smell this gas.



Do not operate generators indoors



Do not operate generators in garage or carport



Do not operate generators near open doors or windows



Recommendations Provided by: Centers for Disease Control and Prevention

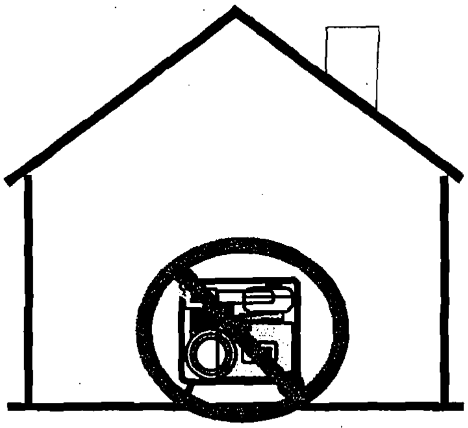
U.S. Consumer Product Safety Commission

# PELIGRO

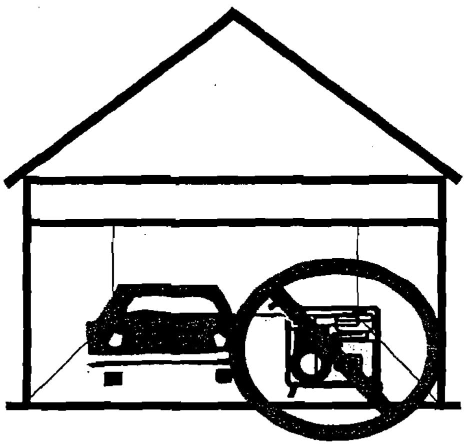
GAS VENENOSO - GAS VENENOSO - GAS VENENOSO

# PELIGRO DE INTOXICACIÓN POR MONÓXIDO DE CARBONO

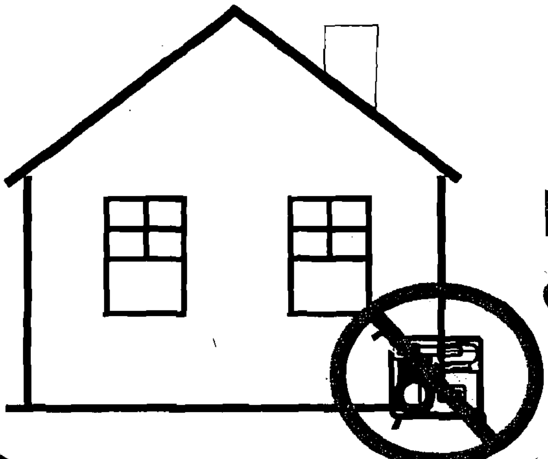
## Los gases pueden ser nocivos o mortales. Este gas NO PUEDE ni verse ni olerse.



**No utilice generadores en sitios cerrados**



**No utilice generadores en garajes o cocheras**



**No utilice generadores cerca de puertas o ventanas**



Recomendaciones de: Centros para el Control y la Prevención de Enfermedades (Centers for Disease Control and Prevention)

Comisión de Seguridad de Productos del Consumidor de los Estados Unidos

# Health Alert*

## Carbon Monoxide Warning!

**Protect yourself and your family from carbon monoxide poisoning (called CO) when using portable generators and pressure washers.**

- **CO cannot be seen or smelled, but it can kill you or make you sick.**
- **Be safe when you're using these machines.**

### BE SAFE:

- **Never use the generator indoors or in a garage, carport, or basement.**
- **Put the generator or pressure washer motor outside and away from doors, windows, and vents.**
- **Read product directions for other safety tips.**
- **Install a battery-operated CO alarm near the bedrooms.**
- **Chain the generator to a tree or other fixed object to prevent theft.**
- **Symptoms of CO poisoning:**

| | |
|---|---|
| Headache | Confusion |
| Fatigue | Seizures |
| Dizziness | Loss of consciousness |
| Nausea/vomiting | Death |

***Get out of the house and seek medical help immediately if you or a family member have these symptoms!***

** Recommendations from the Centers for Disease Control and Prevention and the Consumer Product Safety Commission*

# Carbon Monoxide Warning!

- Protect yourself and your family from carbon monoxide poisoning (called CO) when using portable generators and pressure washers.
- CO cannot be seen or smelled, but it can kill you or make you sick.
- Install a battery-operated CO alarm near the bedrooms.

*Recommendations from the Centers for Disease Control and Prevention*

# Carbon Monoxide Warning!

(CO, carbon monoxide, is a poisonous gas)

**BE SAFE:**

- √ Never use the generator indoors or in a garage, carport, or basement.
- √ Put the generator outside and away from doors, windows, and vents.
- √ Read product directions for other safety tips.
- √ Chain the generator to a tree or other fixed object to prevent theft.
- √ Symptoms of CO poisoning:

| | |
|---|---|
| **Headache** | **Confusion** |
| **Fatigue** | **Seizures** |
| **Dizziness** | **Loss of consciousness** |
| **Nausea/vomiting** | **Death** |

***Get out of the house and seek medical help immediately if you or a family member have these symptoms!***

U.S. CONSUMER PRODUCT SAFETY COMMISSION

# NEWS from CPSC

## U.S. Consumer Product Safety Commission

Office of Information and Public Affairs Washington, DC 20207

FOR IMMEDIATE RELEASE
September 22, 2005
Release #05-276

**CPSC Consumer Hotline: (800) 638-2772**
CPSC Media Contact: Patty Davis: (301) 504-7601

## *Survival Tips After Hurricane Rita Strikes*
## CPSC Warns Gulf Coast Residents of Deadly Carbon Monoxide from Generators

WASHINGTON, D.C. – With Hurricane Rita barreling towards Gulf Coast states, the U.S. Consumer Product Safety Commission (CPSC) warns residents who may lose power, NEVER to use portable generators inside their homes or attached garages. The exhaust from generators contains high levels of carbon monoxide (CO) which can quickly incapacitate and kill.

"Carbon monoxide is an invisible killer, odorless and colorless. Keep generators a safe distance from your home, away from open doors, windows and vents. Don't take a chance," said CPSC Chairman Hal Stratton.

Unofficial estimates indicate at least 11 deaths and numerous injuries have been attributed to carbon monoxide poisoning stemming from portable generators used in the aftermath of Hurricane Katrina.

The Commission provided these important life-saving tips:

- Never use a portable generator indoors – including garages, basements, crawlspaces and sheds. Opening doors and windows or using fans will not prevent CO buildup in the home.
- During use, keep portable generators outdoors and far away from open doors, windows and vents, which can allow CO to build up indoors.
- If you start to feel sick, dizzy or weak while using a generator, get to fresh air right away. The CO from generators can readily lead to full incapacitation and death.
- Keep generators dry and wait for the rain to pass before using a generator. Consumer-grade generators are not weatherproof and can pose the risk of electrocution and shock when used in wet conditions.
- Do not connect the generator directly into your home's electrical system through a receptacle outlet – this is an extremely dangerous practice that poses a fire hazard and an electrocution hazard to utility workers and neighbors served by the same transformer.
- If using a generator, plug individual appliances into heavy duty, outdoor-rated extension cords and plug cords into the generator.
- Check that the extension cords have a wire gauge adequate for the appliance loads and have all three prongs, including a grounding pin.
- Keep charcoal grills outside. Never use them indoors. Burning charcoal in an enclosed space can produce lethal levels of carbon monoxide poisoning.
- Check to make sure your smoke alarms and carbon monoxide alarms have batteries and are working.

### Wet Carpets and Furniture Are Dangerous to your Health

- Discard water-damaged mattresses, wicker furniture, straw baskets and the like that have been water damaged. These cannot be recovered.

- Throw out wet room-size carpets, drapes, upholstered furniture, stuffed toys, ceiling tiles and anything that can't be picked up and cleaned by dry cleaning, steam cleaning or put in a washing machine or dryer.
- Remove and replace wet insulation.
- Microorganisms may grow in these water-damaged products and may cause allergic reactions and infections. For more information, go to http://www.cpsc.gov/CPSCPUB/PUBS/425.html

**Avoid Electrical and Gas Hazards**

- Look for signs that your appliances have gotten wet. Discard electrical or gas appliances that have been wet because they pose electric shock and fire hazards.
- Before using your appliances, have a professional or your gas or electric company evaluate your home and replace all gas control valves, circuit breakers, and fuses that have been under water.

**Dangers to Children**

- Medicines and chemicals should be thrown away. Water may have infected the integrity of the medicine. The U.S. Department of Health and Human Services offers additional safety tips. For more information, go to http://www.hhs.gov/news/broadcast/2005/CrawfordMedicationSafety.html
- Young children and water don't mix. Watch children around buckets, tubs and standing water in and around the home. Even small amounts of water can be a drowning hazard.

Consumers, fire departments and state and local health and safety agencies can download CPSC's generator safety posters (English-pdf) (Spanish-pdf) and door hangers or order hard copies by contacting the Office of Information and Public Affairs.

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Send the link for this page to a friend! The U.S. Consumer Product Safety Commission is charged with protecting the public from unreasonable risks of serious injury or death from more than 15,000 types of consumer products under the agency's jurisdiction. Deaths, injuries and property damage from consumer product incidents cost the nation more than $700 billion annually. The CPSC is committed to protecting consumers and families from products that pose a fire, electrical, chemical, or mechanical hazard or can injure children. The CPSC's work to ensure the safety of consumer products - such as toys, cribs, power tools, cigarette lighters, and household chemicals - contributed significantly to the 30 percent decline in the rate of deaths and injuries associated with consumer products over the past 30 years.

To report a dangerous product or a product-related injury, call CPSC's hotline at (800) 638-2772 or CPSC's teletypewriter at (800) 638-8270, or visit CPSC's web site at www.cpsc.gov/talk.html. To join a CPSC email subscription list, please go to www.cpsc.gov/cpsclist.asp. Consumers can obtain this release and recall information at CPSC's Web site at www.cpsc.gov.

# CPSC Safety Alert

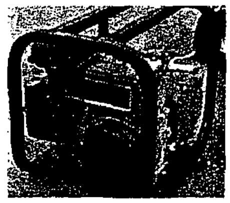
## Surviving the Aftermath of a Hurricane

Deadly dangers can exist after a natural disaster knocks out power or causes flooding. Here is some important safety information to keep in mind.

- Never use a portable generator indoors - including garages, basements, crawlspaces and sheds - even with ventilation. Exhaust fumes contain extremely high levels of carbon monoxide (CO) that can rapidly become deadly if inhaled.

- Only use a portable generator outdoors in a dry area away from doors, windows and vents that can allow CO to come indoors. Wait for the rain to pass before using a generator. Consumer-grade generators are not weatherproof and can pose the risk of electrocution and shock when used in wet conditions.

- If using a generator, plug individual appliances into heavy duty, outdoor-rated extension cords and plug the cords into the generator.



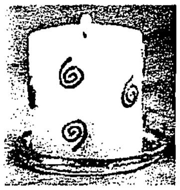
- Check that the extension cords have a wire gauge adequate for the appliance loads and have all three prongs, including a grounding pin.

- Never store gasoline in the home or near a fuel-burning appliance, such as a natural gas water heater, where gasoline fumes could be ignited.

- Never use charcoal indoors. Burning charcoal in an enclosed space can produce lethal levels of carbon monoxide.

- Make sure the batteries in your smoke alarm and carbon monoxide alarm are working.

- Do not use electric or gas appliances that have been wet or damaged because of the hazards of electric shock, fire, or explosion.



- Exercise caution when using candles. Use flashlights instead. If you must use candles, do not burn them on or near anything that can catch fire. Never leave burning candles unattended. Extinguish candles when you leave the room.

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*Advertencia de Seguridad de la CPSC*

# Sobreviviendo a las secuelas de un Huracán

U.S. Consumer Product Safety Commission Washington, DC 20207 www.cpsc.gov 800-638-2772

Los peligros mortales pueden existir después de que un desastre natural corte del suministro eléctrico o resulten inundaciones. La Comisión ofrece los siguientes consejos sobre seguridad:

- Nunca use un generador portátil en interiores, ya sea en garajes, sótanos, espacios entre plantas, o cobertizos, aunque estén ventilados. Los gases de escape contienen altos niveles de monóxido de carbono (CO) que puede resultar mortal si se inhala.

- Sólo use un generador portátil en exteriores al aire libre, en un área seca alejada de puertas, ventanas y salidas de ventilación que pudiesen permitir el ingreso del CO. Espere que pase la lluvia antes de usar un generador. Los generadores de grado de consumidor no son impermeables y pueden resultar en riesgo de electrocución y descargas eléctricas bajo condiciones mojadas.

- Si usa un generador, conecte los electrodomésticos individualmente a extensiones eléctricas de alta resistencia para uso en exteriores y conecte las extensiones al generador de electricidad.

- Verifique que las extensiones tengan un calibre de cable adecuado para las cargas de los aparatos y que el enchufe tenga tres clavijas, en especial la clavija de conexión a tierra.

- Nunca almacene la gasolina en la casa o cerca de un aparato de combustión a gasolina, como por ejemplo un calentador de agua a gas natural, donde los vapores de gasolina podrían ser encendidos.

- Nunca use carbón en interiores. La quema de carbón produce altos niveles de monóxido de carbono que pueden alcanzar niveles letales en espacios cerrados..

- Asegúrese que las pilas en su detector de humo y alarma de monóxido de carbono estén cargadas.

- No use aparatos eléctricos o de gas que han sido mojadas o estén dañados debido a los riesgos de descarga eléctrica, incendio, o explosión.

- Tenga el cuidado usando velas. En lugar de velas, utilice linternas. Si tiene que usar velas, no las queme sobre o cerca de algo que puedan incendiarse. Nunca deje velas encendidas sin supervisión. Apague las velas cuando abandone el cuarto.

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Para más información de seguridad sobre generadores portátiles y otros productos, visite la página Web: www.cpsc.gov.

# CPSC *Safety Alert*: Portable Generator Hazards

U.S. Consumer Product Safety Commission  Washington, DC 20207  www.cpsc.gov  800-638-2772

Portable generators are useful when temporary or remote electric power is needed, but they also can be hazardous. The primary hazards to avoid when using a generator are carbon monoxide (CO) poisoning from the toxic engine exhaust, electric shock or electrocution, and fire.

Every year, people die in incidents related to portable generator use. Most of the incidents associated with portable generators reported to CPSC involve CO poisoning from generators used indoors or in partially-enclosed spaces.

***To avoid CO poisoning when using a portable generator:***

- ***Never run it indoors, including garages, basements, and crawlspaces.***
- ***Get to fresh air right away if you start to feel dizzy or weak.***

## Carbon Monoxide Hazards

NEVER use a generator in enclosed or partially-enclosed spaces. Generators can produce high levels of CO very quickly. When you use a portable generator, remember that you cannot smell or see CO. Even if you can't smell exhaust fumes, you may still be exposed to CO.

If you start to feel sick, dizzy, or weak while using a generator, get to fresh air RIGHT AWAY. DO NOT DELAY. The CO from generators can rapidly lead to full incapacitation and death.

If you experience serious symptoms, get medical attention immediately. Inform medical staff that CO poisoning is suspected. If you experienced symptoms while indoors, have someone call the fire department to determine when it is safe to re-enter the building.

Follow these safety tips to protect against CO poisoning.

- NEVER use a generator indoors, including in homes, garages, basements, crawl spaces, and other enclosed or partially-enclosed areas, even with ventilation. Opening doors and windows or using fans will not prevent CO build-up in the home.
- Follow the instructions that come with your generator. Locate the unit outdoors and away from doors, windows, and vents that could allow CO to come indoors.
- Install battery-operated CO alarms or plug-in CO alarms with battery back-up in your home, according to the manufacturer's installation instructions. The CO alarms should be certified to the requirements of the latest safety standards for CO alarms (UL 2034, IAS 6-96, or CSA 6.19.01).
- Test your CO alarms frequently and replace dead batteries.

## Electrical Hazards

Follow these tips to protect against shock and electrocution.

- Keep the generator dry and do not use in rain or wet conditions. To protect from moisture, operate it on a dry surface under an open, canopy-like structure. Dry your hands if wet before touching the generator.
- Plug appliances directly into the generator. Or, use a heavy duty, outdoor-rated extension cord that is rated (in watts or amps) at least equal to the sum of the connected appliance loads. Check that the entire cord is free of cuts or tears and that the plug has all three prongs, especially a grounding pin.
- NEVER try to power the house wiring by plugging the generator into a wall outlet, a practice known as "backfeeding." This is an extremely dangerous practice that presents an electrocution risk to utility workers and neighbors served by the same utility transformer. It also bypasses some of the built-in household circuit protection devices.
- If you must connect the generator to the house wiring to power appliances, have a qualified electrician install the appropriate equipment in accordance with local electrical codes. Or, check with your utility company to see if it can install an appropriate power transfer switch.
- For power outages, permanently installed stationary generators are better suited for providing backup power to the home. Even a properly connected portable generator can become overloaded. This may result in overheating or stressing the generator components, possibly leading to a generator failure.

## Fire Hazards

Follow these tips to prevent fires.

- Never store fuel for your generator in the home. Gasoline, propane, kerosene, and other flammable liquids should be stored outside of living areas in properly-labeled, non-glass safety containers. Do not store them near a fuel-burning appliance, such as a natural gas water heater in a garage. If the fuel is spilled or the container is not sealed properly, invisible vapors from the fuel can travel along the ground and can be ignited by the appliance's pilot light or by arcs from electric switches in the appliance.
- Before refueling the generator, turn it off and let it cool down. Gasoline spilled on hot engine parts could ignite.

# Generadores Portátiles de Electricidad
## *Peligros*

U.S. Consumer Product Safety Commission Washington, DC 20207 www.cpsc.gov 800-638-2772

**Para evitar el envenenamiento por CO al usar un generador portátil:**

- **Nunca utilice un generador de electricidad en interiores, ya sea en garajes, sótanos, o en espacios entre plantas, aunque estén ventilados.**
- **Si empieza a sentirse enfermo, mareado o débil salga a tomar aire fresco INMEDIATAMENTE.**

Los generadores portátiles de electricidad son de gran utilidad cuando se necesita energía eléctrica provisionalmente o en un lugar remoto, pero también pueden ser peligrosos. Los principales peligros a evitar, al usar un generador portátil son: envenenamiento por monóxido de carbono (CO) causado por la inhalación de gases tóxicos emitidos por el motor, descarga eléctrica o electrocución, e incendio.

Personas mueren cada año en incidentes que involucran el uso de generadores portátiles. La mayoría de los incidentes relacionados con generadores portátiles, que son reportados a la CPSC, involucran envenenamientos por monóxido de carbono causado por el uso de generadores en interiores o en áreas parcialmente encerradas.

**Peligros del Monóxido de Carbono**

NUNCA utilice un generador en interiores o en áreas parcialmente encerradas. Los generadores pueden producir altos niveles de CO rápidamente. Cuando use un generador portátil, recuerde que el CO no se puede oler o ver. Se puede estar expuesto al CO aunque el olor de los gases de escape no se detecte.

Si empieza a sentirse enfermo, mareado o débil al usar un generador salga a tomar aire fresco INMEDIATAMENTE. HAGALO ENSEGUIDA ya que el CO producido por los generadores puede resultar, rápidamente; en la incapacitación total o la muerte.

Si sufre síntomas serios, consulte a un médico inmediatamente. Informe al personal médico sobre su sospecha de estar sufriendo envenenamiento por CO. Si se encontraba en un área encerrada al empezar a sufrir los síntomas, haga que alguien llame al departamento de bomberos para que determinen cuando sea seguro volver a entrar a esa área.

Siga las siguientes recomendaciones de seguridad para protección contra el envenenamiento de CO:

- Nunca utilice un generador de electricidad en interiores, en áreas encerradas o parcialmente encerradas, ya sea en garajes, sótanos, o en espacios entre plantas, aunque estén ventilados. El abrir puertas y ventanas, o usar ventiladores, no prevendrá la acumulación de CO dentro del hogar.
- Al usar un generador portátil, siga las instrucciones de uso proporcionadas por el fabricante. Coloque la unidad al aire libre, alejada de puertas, ventanas y tomas de aire que pudiesen permitir el ingreso del CO a un área encerrada.
- Instale en su hogar alarmas detectoras de CO que funcionen con pilas o alarmas de CO eléctricas con pilas de respaldo en caso de una falla eléctrica. Siga las instrucciones de instalación proporcionadas por el fabricante. Las alarmas de CO deben contar con la certificación de cumplimiento con los más recientes requisitos de seguridad para alarmas de CO (UL 2034, IAS 6-96 o CSA 6.19.01).
- Verifique el funcionamiento de sus alarmas de CO frecuentemente y cámbieles las pilas que ya no sirvan

**Riesgos Eléctricos**

Para protección contra descargas eléctricas y electrocución, siga las siguientes recomendaciones de seguridad:

- Mantenga el generador seco y no lo use bajo condiciones lluviosas o mojadas. Para proteger la unidad de la humedad, utilícela en superficies secas, bajo una estructura similar a un toldo que no esté encerrada. Asegúrese de tener las manos secas antes de tocar el generador.
- Conecte los aparatos eléctricos directamente al generador. O, utilice extensiones eléctricas de alta resistencia o para uso en exteriores con un calibre adecuado de por lo menos igual resistencia (en watts o amps) a la carga eléctrica (suma total) de todos los electrodomésticos conectados. Asegúrese de que cada extensión esté libre de cortes o roturas y verifique que el enchufe tenga tres clavijas, en especial la clavija de conexión a tierra.
- NUNCA trate de generar energía eléctrica en su hogar conectando un generador directamente a un tomacorrientes. Esta es una práctica extremadamente peligrosa ya que los generadores pueden retroalimentar electricidad a las líneas de servicio eléctrico, poniendo en riesgo de electrocución tanto a usted y sus vecinos, como a los empleados que trabajan directamente con las líneas de electricidad. Esta práctica tampoco permite el funcionamiento de los mecanismos de protección de los circuitos eléctricos incorporados en las casas.
- Si debe conectar el generador al sistema de cableado de su casa para encender los aparatos eléctricos, haga que un electricista calificado instale el equipo apropiado de acuerdo al reglamento eléctrico local. O, verifique con su compañía eléctrica si ellos pueden instalar un mecanismo de transferencia eléctrica apropiado.
- La instalación de un generador de reserva (permanente y estacionario) es idóneo para proveer electricidad durante una interrupción de energía eléctrica. Un generador portátil puede experimentar una sobrecarga; aún cuando esté bien conectado. Consecuentemente, los componentes del generador se pudieran sobrecalentar o forzar demasiado, causando que el generador falle.

**Riesgos de Incendio**

Para prevenir incendios, siga las siguientes recomendaciones:

- Nunca almacene combustibles para su generador dentro de su hogar. La gasolina, el gas propano, el kerosene y cualquier otro líquido inflamable deben ser almacenados fuera de las áreas donde habita la gente. Colóquelos en recipientes seguros que no estén hechos de vidrio, etiquetándolos apropiadamente. No los almacene cerca de un aparato de combustión, como por ejemplo un calentador de agua a gas natural en un garaje. Si el combustible se llegara a derramar, o si el recipiente no estuviera bien asegurado, los vapores invisibles del combustible podrían encenderse si llegaran a la flama del calentador o a tener contacto con los arcos eléctricos producidos al encender un electrodoméstico.
- Apague el generador y deje que se enfríe antes de volver a llenar el tanque de combustible. Un derrame de gasolina en las partes de un motor caliente puede provocar que éstas se enciendan.

## What should you do?

Proper installation, operation, and maintenance of fuel-burning appliances in the home is the most important factor in reducing the risk of CO poisoning.

Make sure appliances are installed according to the manufacturer's instructions and the local codes. Most appliances should be installed by professionals.

Always follow the appliance manufacturer's directions for safe operation.

Have the heating system (including chimneys and vents) inspected and serviced annually by a trained service technician.

Examine vents and chimneys regularly for improper connections, visible cracks, rust or stains.

Look for problems that could indicate improper appliance operations:

- Decreased hot water supply
- Furnace unable to heat house or runs continuously
- Sooting, especially on appliances and vents
- Unfamiliar, or burning odor
- Increased moisture inside of windows

Operate portable generators outdoors and away from open doors, windows, and vents that could allow CO to come indoors.

In addition, install battery-operated CO alarms or plug-in CO alarms with battery back-up in your home. Every home should have a CO alarm in the hallway near the bedrooms in each separate sleeping area. The CO alarms should be certified to the requirements of the most recent UL, IAS, or CSA standard for CO alarms. Test your CO alarms frequently and replace dead batteries. A CO alarm can provide added protection, but is no substitute for proper installation, use and upkeep of appliances that are potential CO sources.

## Symptoms of CO poisoning

The initial symptoms of CO poisoning are similar to the flu (but without the fever) They include:

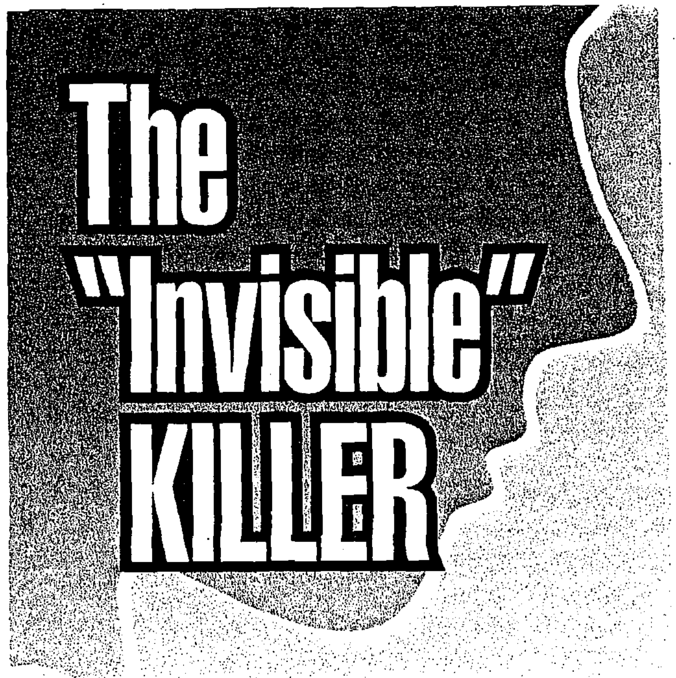
- Headache
- Fatigue
- Shortness of breath
- Nausea
- Dizziness

If you suspect that you are experiencing CO poisoning, get fresh air immediately. Leave the home and call for assistance from a neighbor's home. You could lose consciousness and die from CO poisoning if you stay in the home.

Get medical attention immediately and inform medical staff that CO poisoning is suspected. Call the Fire Department to determine when it is safe to reenter the home.

To report a dangerous product or a product related injury, call CPSC's hotline at (800) 638-2772 or CPSC teletypewriter at (800) 638-8270. Consumers can obtain recall information at CPSC's web site at *http://www.cpsc.gov*. Consumers can report product hazards to *info@cpsc.gov*.

**U.S. Consumer Product Safety Commission**
**Washington, DC 20207**




**Carbon Monoxide (CO) is the "invisible" killer. Carbon monoxide is a colorless and odorless gas. Every year more than 100 people in the United States die from unintentional exposure to carbon monoxide associated with consumer products.**

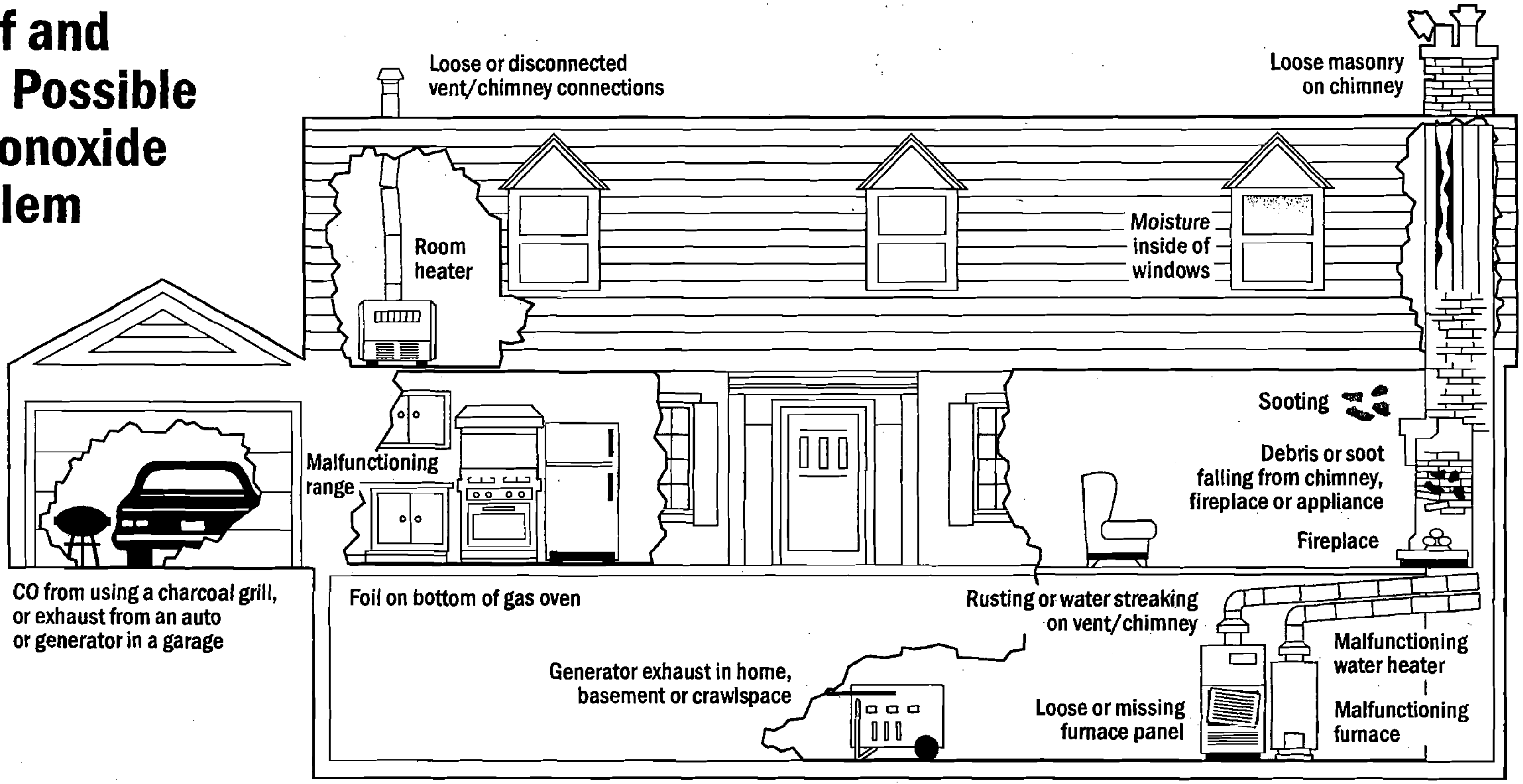
## What is carbon monoxide?

Carbon monoxide is produced by burning fuel. Therefore, any fuel-burning appliance in your home is a potential CO source.

When cooking or heating appliances are kept in good working order, they produce little CO. Improperly operating appliances can produce fatal CO concentrations in your home.

Running a car or generator in an attached garage can cause fatal CO poisoning in the home. So can running a generator or burning charcoal in the basement, crawlspace, or living area of the home.

# Sources of and Clues to a Possible Carbon Monoxide (CO) Problem




## Carbon monoxide clues you can see...

- Rusting or water streaking on vent/chimney
- Loose or missing furnace panel
- Sooting
- Debris or soot falling from chimney, fireplace, or appliances
- Loose or disconnected vent/chimney, fireplace or appliance
- Loose masonry on chimney
- Moisture inside of windows

## Carbon monoxide clues you cannot see...

- Internal appliance damage or malfunctioning components
- Improper burner adjustments
- Hidden blockage or damage in chimneys

Only a trained service technician can detect hidden problems and correct these conditions!

- CO poisoning symptoms have been experienced when you are home, but they lessen or disappear when you are away from home.

## Warnings...

- Never leave a car running in a garage even with the garage door open.
- Never run a generator in the home, garage, or crawlspace. Opening doors and windows or using fans will NOT prevent CO build-up in the home. When running a generator outdoors, keep it away from open windows and doors.
- Never burn charcoal in homes, tents, vehicles, or garages.
- Never install or service combustion appliances without proper knowledge, skills, and tools.
- Never use a gas range, oven, or dryer for heating.
- Never put foil on bottom of a gas oven because it interferes with combustion.
- Never operate an unvented gas-burning appliance in a closed room or in a room in which you are sleeping.

# NEWS from CPSC

## U.S. Consumer Product Safety Commission

Office of Information and Public Affairs Washington, DC 20207

FOR IMMEDIATE RELEASE
August 12, 2004
Release # 04-197

**CPSC Consumer Hotline: (800) 638-2772**
CPSC Media Contacts: Ken Giles, (301) 504-7052, and Eric Criss, (301) 504-7908

### *Surviving the Aftermath of a Hurricane, Tornado, or Flood*
### CPSC Warns of Post-Storm Hazards from Generators, Candles, and Wet Appliances

WASHINGTON, D.C. – The U.S. Consumer Product Safety Commission warns of dangers from generators, candles, and wet appliances after a natural disaster such as a hurricane, tornado, or flood knocks out electricity. The Commission offers these safety tips:

- Never use a generator indoors, including garages, basements, and crawlspaces, even with ventilation. Exhaust fumes contain high levels of carbon monoxide (CO) which can be deadly if inhaled. Use a portable generator outdoors in a dry area away from doors, windows, and vents that could allow CO to come indoors. Never store gasoline in the home or near a fuel-burning appliance, such as a natural gas water heater in a garage where gasoline fumes could be ignited. CPSC has more details about safe use of generators at: www.cpsc.gov/CPSCPUB/PUBS/portgen.pdf

- Plug individual appliances into heavy duty, outdoor-rated extension cords and plug the cords into the generator. Check that the extension cords have a wire gauge adequate for the appliance loads. Make sure that each cord is free of cuts or tears and its plug has all three prongs, especially a grounding pin.

- Do not use electrical or gas appliances that have been wet and do not turn on damaged appliances because of the hazards of electric shock or fire. Do not use gas appliances that have been submerged because silt can make valves inoperable, leading to a gas leak or fire.

- Never use charcoal indoors because burning charcoal produces high levels of carbon monoxide that can reach lethal levels in enclosed spaces.

- Make sure the batteries in your smoke alarm and carbon monoxide alarm are fresh. Test these alarms to make sure they are working.

- Exercise caution when using candles. Use flashlights instead. If you must use candles, do not burn them on or near anything that can catch fire. Keep burning candles away from drafts. Never leave burning candles unattended. Extinguish candles when you leave the room.

Consumers can also view a video clip about surviving the aftermath of a storm (standard version or a higher quality version - broadband connection recommended) (transcript). This is in "streaming video" format.

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Send the link for this page to a friend! The U.S. Consumer Product Safety Commission is charged with protecting the public from unreasonable risks of serious injury or death from more than 15,000 types of consumer products under the agency's jurisdiction. Deaths, injuries and property damage from consumer product incidents cost the nation more than $700 billion annually. The CPSC is committed to protecting consumers and families from products that pose a fire, electrical, chemical, or mechanical hazard or can injure children. The CPSC's work to ensure the safety of consumer products - such as toys, cribs, power tools, cigarette lighters, and household chemicals - contributed significantly to the 30 percent decline in the rate of deaths and injuries associated with consumer products over the past 30 years.

To report a dangerous product or a product-related injury, call CPSC's hotline at (800) 638-2772 or CPSC's teletypewriter at (800) 638-8270, or visit CPSC's web site at www.cpsc.gov/talk.html. To join a CPSC email subscription list, please go to www.cpsc.gov/cpsclist.asp. Consumers can obtain this release and recall information at CPSC's Web site at www.cpsc.gov.

# NEWS from CPSC and FEMA

## U.S. Consumer Product Safety Commission
## Federal Emergency Management Agency

Office of Information and Public Affairs Washington, DC 20207

FOR IMMEDIATE RELEASE
January 22, 2003
Release # 03-073

CPSC Consumer Hotline: (800) 638-2772
CPSC Media Contact: Ken Giles, (301) 504-7052
FEMA Media Contact: Lara Shane (202) 646-4600

# CPSC and FEMA Warn: When A Storm Knocks Out Power, Don't Risk Carbon Monoxide Poisoning by Using Gasoline-Powered Generators Indoors

WASHINGTON, D.C. - When disaster strikes and the power goes out, many Americans turn to their gas-powered generators for heat and electricity. But when they set up those generators inside, a second disaster may strike - carbon monoxide poisoning.

The U.S. Consumer Product Safety Commission (CPSC) and the Federal Emergency Management Agency (FEMA) have joined forces to warn residents not to use gasoline-powered generators or charcoal grills indoors or in attached garages because of the risk of carbon monoxide (CO) poisoning. "If you want to use a gasoline-powered generator when the power goes out, set it up outside in a dry area, away from air intakes to the home," said CPSC Chairman Hal Stratton. "And never use a charcoal grill inside because you risk being poisoned by deadly carbon monoxide. Opening doors and windows or operating fans to ventilate is inadequate and unsafe. Even with a CO alarm, you should never use a gasoline- powered generator or a charcoal grill inside. "

"People often turn to substitutes like gasoline-powered generators when storms, floods and other natural disasters interrupt power services," said FEMA Deputy Director Mike Brown. "In preparing for disasters, it is critical for people to identify and know the proper way to use generators."

CO is a colorless, odorless gas produced by burning fuel. The initial symptoms of CO poisoning are similar to the flu, and include dizziness, fatigue, headache, nausea and irregular breathing. Exposure to high levels of CO can cause death. CO poisoning from fuel-burning appliances kills more than 170 people each year. Others die from CO produced while burning charcoal inside a home, garage, vehicle or tent. Still more deaths happen when cars are left running in an attached garage.

"Every home should have a CO alarm that meets the most current safety standards," advised Chairman Stratton. Those standards are: Underwriters Laboratories 2034 (second edition 1998); International Approval Services 6-96 (second edition 1998); or Canadian Standards Association 6.19-01 (2001).

FEMA and CPSC also warn about CO hazards when gas ranges are used to heat homes. In addition, to prevent fires, space heaters should not be used while you are sleeping and should be kept away from flammable materials and turned off when the consumer leaves the room.

Bags of charcoal are labeled to warn about the hazard of burning charcoal indoors. The labels say: "Warning! Carbon Monoxide Hazard. Burning charcoal inside can kill you. It gives off carbon monoxide, which has no odor. NEVER burn charcoal inside homes, vehicles or tents."

Emergency management officials also suggest that other options to consider when power is interrupted from storms include checking into hotels or staying in designated shelters.



For more information on safe use of generators, read this CPSC publication:

www.cpsc.gov/CPSCPUB/PUBS/portgen.html

Consumers can also view a video clip about gasoline-powered generators and CO poisoning (transcript). This is in "streaming video" format.

Soundbites of CPSC Chairman Hal Stratton are also available here (in WAV format; about 1.5 megabytes in length) on gasoline-powered generators (transcript).

Soundbites in Spanish of CPSC Chairman Hal Stratton are also available here (in WAV format; about 2 megabytes in length) (transcripción) on gasoline-powered generators.

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Send the link for this page to a friend! The U.S. Consumer Product Safety Commission is charged with protecting the public from unreasonable risks of serious injury or death from more than 15,000 types of consumer products under the agency's jurisdiction. Deaths, injuries and property damage from consumer product incidents cost the nation more than $700 billion annually. The CPSC is committed to protecting consumers and families from products that pose a fire, electrical, chemical, or mechanical hazard or can injure children. The CPSC's work to ensure the safety of consumer products - such as toys, cribs, power tools, cigarette lighters, and household chemicals - contributed significantly to the 30 percent decline in the rate of deaths and injuries associated with consumer products over the past 30 years.

To report a dangerous product or a product-related injury, call CPSC's hotline at (800) 638-2772 or CPSC's teletypewriter at (800) 638-8270, or visit CPSC's web site at www.cpsc.gov/talk.html. To join a CPSC email subscription list, please go to www.cpsc.gov/cpsclist.asp. Consumers can obtain this release and recall information at CPSC's Web site at www.cpsc.gov.

# Noticias de la CPSC

## Comisión para la Seguridad de los Productos de Consumode los Estados Unidos

Oficina de Información y Asuntos Públicos Washington, DC 20207

Para Publicación Inmediata
22 de Enero del 2003
Publicación # 03-073

Línea Urgente Gratuita de la CPSC: (800) 638-2772
Contacto en la CPSC para los Medios de Comunicación: Carla Coolman, (301) 504-7054
Contacto en la FEMA para los Medios de Comunicación: Lara Shane, (202) 646-4600

## La CPSC y FEMA Advierten: Cuando una Tormenta Corte la Energía Eléctrica, No Arriesgue el Sufrir Envenenamiento por Monóxido de Carbono al Usar Generadores (que funcionan con Gasolina) en Áreas Cerradas

WASHINGTON, D.C. - Cuando ocurre un desastre y el suministro de energía eléctrica falla, muchas personas usan sus generadores de electricidad que funcionan con gasolina, para producir calor y electricidad. Pero, cuando esos generadores son usados dentro del hogar o en otras áreas cerradas, otro desastre puede ocurrir - envenenamiento por monóxido de carbono.

La Comisión para la Seguridad de los Productos de Consumo de los Estados Unidos (CPSC) y la Agencia Federal para el Manejo de Emergencias (FEMA) han unido fuerzas para advertirle a los consumidores que no deben usar generadores de electricidad que funcionan con gasolina o parrillas de carbón, en áreas cerradas, como en el hogar, o en un garaje adjunto, debido al riesgo de envenenamiento por monóxido de carbono (CO). "Si usted quiere usar un generador de electricidad, que funciona con gasolina, cuando el suministro de energía eléctrica falle, póngalo afuera, en un área seca y lejos de las entradas de aire a la casa" -dijo el Presidente de la CPSC, Hal Stratton. "Y nunca use parrillas de carbón en áreas cerradas, como dentro de su hogar, porque al hacerlo, está arriesgando el sufrir envenenamiento por el mortal monóxido de carbono. El abrir puertas o ventanas o encender los abanicos para ventilar, no es adecuado ni seguro. Aunque usted tenga una alarma de detección de monóxido de carbono, nunca debe usar un generador (que funcione con gasolina) o una parrilla de carbón dentro de su hogar o en cualquier otra área cerrada."

"Muchas veces, cuando tormentas, inundaciones y otros desastres naturales ocurren e interrumpen el suministro de electricidad, las personas usan substitutos como generadores que funcionan con gasolina" -dijo el Vicepresidente de FEMA, Mike Brown. "Al prepararse para desastres, es crítico que las personas identifiquen y conozcan la manera correcta de usar generadores de electricidad."

El CO es un gas sin olor ni color que es producido al quemar combustible. Los síntomas iniciales del envenenamiento por CO son similares a los de la gripe e incluyen: mareos, fatiga, dolor de cabeza, nauseas y respiración irregular. El estar expuesto a altos niveles de CO puede causar la muerte. El envenenamiento por CO, debido a aparatos de combustión, es la causa de más de 170 muertes anuales. Otras personas mueren por el CO producido al quemar carbón dentro de una casa, un garaje, un vehículo o una tienda de campaña. Todavía, además, otras muertes ocurren cuando los autos se dejan encendidos dentro del garaje.

"Cada hogar debe tener una alarma de detección de CO que cumpla con los estándares de seguridad más actuales" -aconsejo el Presidente Stratton. Esos estándares son: Underwriters Laboratories 2034 (segunda edición 1998); International Approval Services 6-96 (segunda edición 1998) o Canadian Standards Association

6.19-01 (2001).

La FEMA y la CPSC también advirtieron sobre los riesgos del monóxido de carbono cuando las personas usan estufas de gas para calentar sus casas. Además, para prevenir incendios, los calentadores no se deben usar mientras uno esté durmiendo y deben de ser colocados lejos de materiales inflamables y apagados al salir de la habitación.

Las bolsas de carbón están etiquetadas con una advertencia acerca del riesgo de quemar carbón en áreas cerradas. Las etiquetas dicen en inglés: "Warning! Carbon Monoxide Hazard. Burning charcoal inside can kill you. It gives off carbon monoxide, which has no odor. NEVER burn charcoal inside homes, vehicles or tents."

Oficiales del manejo de emergencias sugirieron también que dentro de las otras opciones a considerar (cuando las tormentas corten la energía eléctrica) están el registrarse a un hotel o un centro de refugio designado.

Para más información sobre el uso seguro de generadores, lea la siguiente publicación de la CPSC: www.cpsc.gov/CPSCPUB/PUBS/portgen.html

La línea urgente de llamadas telefónicas gratuitas y el sitio Web de la CPSC proporcionan información acerca de los productos retirados del mercado e información sobre qué considerar al comprar productos. Los consumidores pueden tener acceso a la línea urgente llamando al número 800-638-2772 o dirigiéndose a la dirección electrónica http://www.cpsc.gov. Para obtener una lista de los principales productos retirados del mercado, los consumidores deberán enviar una tarjeta postal a: "Recall List", CPSC, Washington, D.C. 20207.

U.S. Consumer Product Safety Commission

# CPSC and GAMA NEWS

gama
Gas Appliance Manufacturers Association

FOR IMMEDIATE RELEASE
October 25, 2005
Release #06-015

CPSC Consumer Hotline: (800) 638-2772
CPSC Media Contact: Patty Davis, (301) 504-7908
GAMA Contact: Michael Blevins, (703) 525-7060 x235

***CPSC and GAMA Issue Consumer Alert***

## Don't Forget to Replace Smoke and CO Alarm Batteries This Weekend as Daylight Saving Time Ends

WASHINGTON, D.C. – The U.S. Consumer Product Safety Commission (CPSC) and the Gas Appliance Manufacturers Association (GAMA) are joining forces to urge consumers to replace the batteries in their smoke alarms and carbon monoxide (CO) alarms when changing their clocks this Sunday, October 30th.

"Working smoke and CO alarms can help protect your family from a fire or carbon monoxide (CO) hazard in your home," said CPSC Chairman Hal Stratton. "Take the time to put fresh batteries in your alarms. That simple step could save your life."

"CO is a colorless, odorless, toxic gas that consumers cannot see or smell," said GAMA President Jack Klimp. "We are concerned that consumers may not be sufficiently aware of all the potential sources for CO in the home. These sources include an automobile engine running in an attached garage; a fuel-burning appliance that is installed improperly or connected to a blocked or leaking vent system; or a portable gasoline-powered generator, charcoal grill or camp stove improperly used indoors."

In addition to replacing batteries in smoke and CO alarms at least once every year, CPSC recommends testing them monthly. Smoke alarms should be placed on every level of your home, outside each sleeping area and inside each bedroom. CO alarms should be installed outside each sleeping area. Battery backup is an important consideration for those alarms that are powered by your home's electrical system.

In 1999, an estimated 2,390 people died in residential fires, 14,550 were injured and 337,000 residential fires were reported to fire departments.

Recent studies indicate that children under 16 and hearing-impaired older adults may not always be awakened by smoke alarms. Therefore, CPSC recommends that home fire escape plans factor in a family member who does not respond to the smoke alarm and that escape drills be practiced during the day and night. CPSC staff is looking into ways to improve smoke alarm audibility for children as well as hearing-impaired older adults.

While about 90 percent of homes have smoke alarms, far fewer have carbon monoxide alarms. Between 1999 and 2002, carbon monoxide associated with consumer products killed an average of about 140 people each year.

According to CPSC and GAMA, a CO alarm provides an added measure of protection against carbon monoxide poisoning from all potential sources in the home. The best way to make sure that gas appliances do not become a source of CO is to have a professional inspect your installed appliances annually.

Remember to never use gasoline-powered generators, camp stoves, and charcoal grills indoors or in enclosed spaces. They can generate high levels of deadly carbon monoxide.

Both CPSC and GAMA recommend consumers purchase CO alarms that meet the requirements of UL 2034 or CSA 6.19.

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# Safety Alert

## U.S. Consumer Product Safety Commission

Office of Information and Public Affairs Washington, DC 20207

FOR IMMEDIATE RELEASE
August 15, 2003
Release # 03-170

CPSC Media Contact: Scott Wolfson, (301) 504-7051
CPSC Media Line: (301) 504-7800

## CPSC Warns of Dangers of Generators and Candles During Power Outage

WASHINGTON D.C. – The U.S. Consumer Product Safety Commission urges consumers to exercise caution when using generators and candles during the power outage currently affecting portions of the Northeast. It offers the following important safety tips:

- Shut off all unnecessary electrical appliances and equipment.
- If you have a portable generator, only run it outdoors with adequate ventilation. Never use a generator indoors or in attached garages. Exhaust fumes contain carbon monoxide, which can be deadly if inhaled.
- Plug individual appliances into the generator using heavy duty, outdoor rated cords with a wire gauge adequate for the appliance load.
- Make sure that the battery in your smoke detector is fresh. Test the smoke detector to make sure it's working.
- Avoid the use of candles if at all possible. Instead use flashlights or glowsticks. If you must use candles do not put them on or near anything that will burn. And never leave burning candles unattended.

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# NEWS from CPSC

## U.S. Consumer Product Safety Commission

Office of Information and Public Affairs | Washington, DC 20207

FOR IMMEDIATE RELEASE
September 15, 2002
Release # 03-184

CPSC Consumer Hotline: (800) 638-2772
CPSC Media Contact: Ken Giles, (301) 504-7052

# *Safety Tips if Hurricane Knocks Out Electricity*
# CPSC Warns of Dangers from Generators and Candles

WASHINGTON, D.C. - The U.S. Consumer Product Safety Commission warns of dangers from generators, candles, and other products that might be used if Hurricane Isabel knocks out electricity. The commission offers these safety tips:

- Never use a generator indoors or in a garage.. Exhaust fumes contain carbon monoxide which can be deadly if inhaled. Use a portable generator outdoors in a dry, ventilated area away from attached garages or air intakes to the house. Do not store gasoline in the basement or in an attached garage where gasoline fumes could be ignited. CPSC has more details about safe use of generators at: www.cpsc.gov/CPSCPUB/PUBS/portgen.html

- Plug individual appliances into the generator using heavy-duty outdoor-rated cords with a wire gauge adequate for the appliance load.

- Do not use electrical appliances that have been wet. Do not turn on damaged electrical appliances because of the hazards of electric shock or fire.

- Never use charcoal indoors because burning charcoal gives off carbon monoxide.

- Make sure the batteries in your smoke alarm and carbon monoxide alarm are fresh. Test these alarms to make sure they are working.

- Exercise caution in the use of candles. Use flashlights instead. If you use candles, do not put them on or near anything that will burn. Never leave burning candles unattended. Douse candles when you leave the room.

# NEWS from CPSC

## U.S. Consumer Product Safety Commission

Office of Information and Public Affairs Washington, DC 20207

FOR IMMEDIATE RELEASE
February 28, 2001
Release # 01-095

CPSC Consumer Hotline: (800) 638-2772
CPSC Media Contact: Ken Giles, (301) 504-7052

# CPSC Warns Earthquake Victims: Do Not Use Gasoline-Powered Generators Indoors Because of Carbon Monoxide Poisoning

WASHINGTON, D.C. - The U.S. Consumer Product Safety Commission (CPSC) is warning residents hit by the earthquake in the Pacific Northwest not to use gasoline-powered generators indoors because of the risk of carbon monoxide (CO) poisoning. Deaths from CO poisoning have occurred when generators were used after electricity was knocked out during other disasters such as ice storms and floods.

CPSC Chairman Ann Brown said, "If people use gasoline-powered generators indoors, they could die from CO poisoning. Opening doors and windows or operating fans does not guarantee safety."

CO poisoning from the use of fuel-burning appliances kills more than 200 people each year and sends about 10,000 to hospital emergency rooms for treatment. Others die from CO produced while burning charcoal inside a home, garage, vehicle or tent.

CO is a colorless, odorless gas produced by burning any fuel. The initial symptoms of CO poisoning are similar to the flu, and include dizziness, fatigue, headache, nausea and irregular breathing. Exposure to high levels of CO can cause death.

"Gasoline-powered generators should be left outdoors at all times to prevent CO poisoning," Brown said. "And every home should have a CO alarm that meets the requirements of the most recent Underwriters Laboratories or International Approval Services standard."

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# NEWS from CPSC

## U.S. Consumer Product Safety Commission

Office of Information and Public Affairs — Washington, DC 20207

FOR IMMEDIATE RELEASE
December 28, 2000
Release # 01-063

CPSC Consumer Hotline: (800) 638-2772
CPSC Media Contact: Ken Giles, (301) 504-7052

# CPSC Warns Winter Storm Victims: *Do Not Use Gasoline-Powered Generators Indoors Because of Carbon Monoxide Poisoning*

WASHINGTON, D.C. - The U.S. Consumer Product Safety Commission is warning residents in areas hit by this week's winter storm that gasoline-powered generators should not be used indoors because of the risk of carbon monoxide (CO) poisoning. Deaths from CO poisoning have occurred after ice storms in the past.

CPSC Chairman Ann Brown said, "If people use gasoline-powered generators indoors, they could die from CO poisoning. Opening doors and windows or operating fans does not guarantee safety."

CO poisoning from the use of fuel-burning appliances kills more than 200 people each year and sends about 10,000 to hospital emergency rooms for treatment. Others die from CO produced while burning charcoal inside a home, garage, vehicle or tent.

CO is a colorless, odorless gas produced by burning any fuel. The initial symptoms of CO poisoning are similar to the flu, and include dizziness, fatigue, headache, nausea and irregular breathing. Exposure to high levels of CO can cause death.

"Gasoline-powered generators should be left outdoors at all times to prevent CO poisoning," Brown said. "And every home should have a CO alarm that meets the requirements of the most recent Underwriters Laboratories or International Approval Services standard."

In addition, the safety agency is warning about fire and CO hazards from space heaters and kitchen ranges used to heat the home. Keep space heaters away from flammable materials and turn them off when you leave the room. Do not use a space heater while you sleep, and never use a kitchen range to heat a room. These appliances can ignite nearby combustibles or produce carbon monoxide, either of which could be fatal.

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# NEWS from CPSC

## U.S. Consumer Product Safety Commission

Office of Information and Public Affairs Washington, DC 20207

FOR IMMEDIATE RELEASE
January 13, 1998
Release # 98-056

CPSC Consumer Hotline: (800) 638-2772
CPSC Media Contact: Ken Giles, (301) 504-7052

# Warning to Storm Victims: Do Not Use Gasoline-Powered Generators Indoors Because of Carbon Monoxide Poisoning

WASHINGTON, D.C. - The U.S. Consumer Product Safety Commission is warning storm victims that gasoline-powered generators should not be used indoors, because of the risk of carbon monoxide (CO) poisoning. Deaths from CO poisoning have occurred in New England after last week's ice storm.

CPSC Chairman Ann Brown said, "If people use gasoline-powered generators indoors, they could die from CO poisoning. Opening doors and windows or operating fans does not guarantee safety."

CO poisoning from the use of fuel-burning appliances kills more than 200 people each year and sends about 10,000 to hospital emergency rooms for treatment. Others die from CO produced while burning charcoal inside a home, garage, vehicle or tent. Still others die from CO produced by cars unintentionally left running in attached garages.

CO is a colorless, odorless gas produced by burning any fuel. The initial symptoms of CO poisoning are similar to the flu, and include dizziness, fatigue, headache, nausea and irregular breathing. High level exposure to CO can cause death.

"CPSC recommends that consumers use gasoline-powered generators outdoors to prevent CO poisoning," Brown said. "And every home should have at least one CO detector that meets the requirements of the most recent Underwriters Laboratories standard 2034 or the requirements of the IAS 6-96 standard."

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# Portable Generator Hazards

A Factsheet on Portable Generator Safety

Portable generators are useful when temporary or remote electric power is needed, but they can be hazardous. The primary hazards to avoid when using them are carbon monoxide poisoning, electric shock or electrocution, and fire.

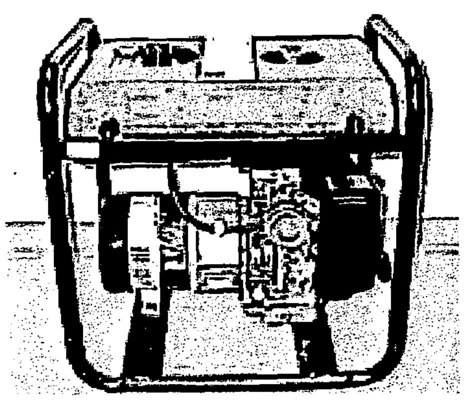
The United States Fire Administration (USFA) would like you to know that there are simple steps you can take to prevent the loss of life and property resulting from improper use of portable generators.

**TO AVOID CARBON MONOXIDE HAZARDS:**

- Always use generators outdoors, away from doors, windows and vents.
- NEVER use generators in homes, garages, basements, crawl spaces, or other enclosed or partially enclosed areas, even with ventilation.
- Follow manufacturer's instructions.
- Install battery-operated or plug-in (with battery backup) carbon monoxide (CO) alarms in your home, following manufacturer's instructions.
- Test CO alarms often and replace batteries when needed.

**TO AVOID ELECTRICAL HAZARDS:**

- Keep the generator dry. Operate on a dry surface under an open, canopy-like structure.
- Dry your hands before touching the generator.
- Plug appliances directly into generator or use a heavy-duty outdoor-rated extension cord. Make sure entire extension cord is free of cuts or tears and the plug has all 3 prongs, especially a grounding pin.
- NEVER plug the generator into a wall outlet. This practice, known as back-feeding, can cause an electrocution risk to utility workers and others served by the same utility transformer.



- If necessary to connect generator to house wiring to power appliances, have a qualified electrician install appropriate equipment. Or, your utility company may be able to install an appropriate transfer switch.

**TO AVOID FIRE HAZARDS:**

- Before refueling the generator, turn it off and let it cool. Fuel spilled on hot engine parts could ignite.
- Always store fuel outside of living areas in properly labeled, non-glass containers.
- Store fuel away from any fuel-burning appliance.

**For More Information Contact:**
**The United States Fire Administration**

National Fire Programs Division
16825 South Seton Avenue
Emmitsburg, MD 21727

**Or visit the USFA Web site: www.usfa.fema.gov**

**Visit our Kid's Page: www.usfa.fema.gov/kids**

Information for this fact sheet was provided by the Consumer Product Safety Commission.

FEMA

American Red Cross

# Fact Sheet: Using a Generator When Disaster Strikes

The following information, developed by the Red Cross with technical advice from the Centers for Disease Control and Prevention, the National Fire Protection Association (publisher of the *National Electric Code®*) and the U. S. Consumer Product Safety Commission, is provided to address questions about using a generator when disaster strikes.

## Purchasing a Generator

If you choose to buy a generator, make sure you get one that is rated for the amount of power that you think you will need. Look at the labels on lighting, appliances, and equipment you plan to connect to the generator to determine the amount of power that will be needed to operate the equipment.

For lighting, the wattage of the light bulb indicates the power needed. Appliances and equipment usually have labels indicating power requirements on them. Choose a generator that produces more power than will be drawn by the combination of lighting, appliances, and equipment you plan to connect to the generator including the initial surge when it is turned on. If your generator does not produce adequate power for all your needs, plan to stagger the operating times for various equipment.

If you can not determine the amount of power that will be needed, ask an electrician to determine that for you. (If your equipment draws more power than the generator can produce, then you may blow a fuse on the generator or damage the connected equipment.)

## Using a Generator

The primary hazards to avoid when using a generator are carbon monoxide (CO) poisoning from the toxic engine exhaust, electric shock or electrocution, and fire. Follow the directions supplied with the generator. Every year, people die in incidents related to portable generator use.

**Under no circumstances should portable generators be used indoors**, including inside a garage, carport, basement, crawlspace, or other enclosed or partially-enclosed area, even with ventilation. Opening doors and windows or using fans will not prevent CO buildup in the home. The CO from generators can rapidly lead to full incapacitation and death, but CO can't be seen or smelled. Even if you cannot smell exhaust fumes, you may still be exposed to CO. If you start to feel sick, dizzy, or weak while using a generator, get to fresh air RIGHT AWAY - DO NOT DELAY.

Because you may have windows open to get fresh air while the power is out, be sure to place the generator away from windows, doors, and vents that could allow CO to come indoors. To avoid electrocution, keep the generator dry and do not use in rain or wet conditions. To protect the generator from moisture, operate it on a dry surface under an open canopy-like structure, such as under a tarp held up on poles. Dry your hands if wet before touching the generator.

It is a good idea to install battery-operated CO alarms or plug-in CO alarms with battery back-up in your home, according to the manufacturer's installation instructions. If CO gas from the generator enters your home and poses a health risk, the alarm will sound to warn you. Test the battery frequently and replace when needed.

**Be sure to turn the generator off and let it cool down before refueling.** Gasoline spilled on hot engine parts could ignite.

Store fuel for the generator in an approved safety can. Use the type of fuel recommended in the instructions or on the label on the generator. Local laws may restrict the amount of fuel you may store, or the storage location. Ask your local fire department for additional information about local regulations. Store the fuel outside of living areas in a locked shed or other protected area. Do not store it near a fuel-burning appliance, such as a natural gas water heater in a garage. If the fuel is spilled or the container is not sealed properly, invisible vapors from the fuel can travel along the ground and can be ignited by the appliance's pilot light or by arcs from electric switches in the appliance.

**Plug appliances directly into the generator. Or, use a heavy duty, outdoor-rated extension cord** that is rated (in watts or amps) at least equal to the sum of the connected appliance loads. Check that the entire cord is free of cuts or tears and that the plug has all three prongs, especially a grounding pin. Never try to power the house wiring by plugging the generator into a wall outlet, a practice known as "backfeeding." This is an extremely dangerous practice that presents an electrocution risk to utility workers and neighbors served by the same utility transformer. It also bypasses some of the built-in household protection devices.

## Future Considerations

The only recommended method to connect a generator to house wiring is by having a qualified electrician install a power transfer switch. This switch must be installed in accordance with the *National Electrical Code®* (NEC), which is published by the National Fire Protection Association, and all applicable state and local electrical codes. Call a qualified electrician or check with your utility company to see if they can install the appropriate equipment.

For power outages, permanently installed stationary generators are better suited for providing backup power to the home. Even a properly connected portable generator can become overloaded. This may result in overheating or stressing the generator components, possibly leading to a generator failure. Be sure to read instructions that come with the generator to make sure you operate it within its limitations for power output.

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This information was developed by the American Red Cross with technical advice from the National Fire Protection Association (publisher of the National Electric Code®) and the U.S. Consumer Product Safety Commission.

Revised and updated September 2004.

**Cruz Roja Americana**

# Hoja informativa: El uso de generadores en casos de desastre

Esta hoja informativa se facilita al público para responder a preguntas sobre el uso de generadores en casos de desastre. La información fue elaborada por la Cruz Roja con el asesoramiento técnico de los Centros para el Control y la Prevención de las Enfermedades (CDC), la Asociación Nacional de Protección contra Incendios (NAFP) –que publica el Código Eléctrico Nacional (*National Electric Code®*)– y la Comisión para la Seguridad de los Productos de Consumo de los Estados Unidos (CPSC).

**Cómo comprar un generador**
Si decide comprar un generador, asegúrese de que tenga la potencia que usted cree que va a necesitar. Mire las etiquetas de las lámparas, aparatos y equipos que va a conectar al generador para averiguar la potencia que será necesaria para que el equipo funcione.

Para las lámparas, la potencia necesaria está indicada por los vatios que figuran en la bombilla. Los aparatos y equipos suelen llevar etiquetas que indican los requisitos de potencia. Elija un generador que produzca más potencia que la que exigirá la suma de las luces, aparatos y equipos que va a conectar al generador, incluida la subida de tensión inicial, cuando se enciende. Si su generador no produce suficiente potencia para cubrir todas sus necesidades, planifique la forma de alternar el funcionamiento de los diferentes aparatos.

Si no puede calcular cuánta potencia será necesaria, pídale a un electricista que lo haga. (Si su equipo necesita más potencia de la que puede producir el generador, podría hacer saltar un fusible del generador o dañar el equipo conectado.)

**Cómo usar un generador**
Los principales riesgos que debe usted evitar al usar un generador son la intoxicación por monóxido de carbono (CO) producido por los gases de escape tóxicos del motor, la descarga eléctrica o la electrocución, y los incendios. Siga las instrucciones que vienen con el generador. Todos los años hay personas que pierden la vida en incidentes relacionados con el uso de generadores portátiles.

**En ninguna circunstancia debe utilizar un generador portátil dentro de la casa**, ni siquiera en garajes, estructuras abiertas para estacionar (techadas o bajo toldos), sótanos, espacios para conductos/cables/tuberías, y otros espacios cerrados o parcialmente cerrados, aunque tengan ventilación. Abrir puertas y ventanas o usar ventiladores no impide que se acumule el monóxido de carbono en la casa. El monóxido de carbono de los generadores es invisible y no tiene olor, lo cual aumenta el peligro ya que puede producir rápidamente la incapacitación y la muerte. Es posible que se exponga al monóxido de carbono aunque no huela a gas. Si empieza a sentir náuseas, mareo o debilitamiento mientras usa un generador, SALGA AL AIRE LIBRE DE INMEDIATO, SIN DEMORAS.

Dado que probablemente tenga las ventanas abiertas para que entre aire fresco mientras no haya electricidad, asegúrese de colocar el generador lejos de ventanas, puertas y rejillas de ventilación que puedan permitir que el monóxido de carbono pase al interior. Para evitar la electrocución, mantenga el generador seco y no lo use bajo la lluvia o con humedad. Para protegerlo contra la humedad, ponga el generador sobre una superficie seca alejada de la vivienda bajo una especie de toldo, por ejemplo bajo una lona impermeable sostenida por varas o colgada de cuerdas. Si tiene las manos húmedas, séqueselas antes de tocar el generador.

*-continúa-*

Una buena idea es colocar alarmas de monóxido de carbono que funcionen a pilas o alarmas de monóxido de carbono eléctricas con pilas de refuerzo, siguiendo las instrucciones de instalación del fabricante. La alarma sonará si entra monóxido de carbono del generador en su casa y peligra su salud. Asegúrese de probar las pilas con frecuencia y cambiarlas cuando sea necesario.

**Asegúrese de apagar el generador y dejarlo enfriar antes de agregar combustible.** La gasolina derramada sobre las piezas calientes del motor podría causar un incendio.

Guarde el combustible para el generador en un envase de seguridad aprobado. Utilice el tipo de combustible recomendado en las instrucciones o en la etiqueta del generador. A veces las leyes locales limitan la cantidad de combustible que puede almacenar o el lugar de almacenamiento. Pida a su departamento de bomberos más información sobre las normas locales. Guarde el combustible FUERA de las zonas destinadas a vivienda, en un cobertizo bajo llave o en otra zona protegida. No lo guarde cerca de un aparato que use combustible, como un calentador de agua de gas natural en un garaje. Si se derrama el combustible o el envase no está bien cerrado, los vapores invisibles que salen del envase pueden moverse por el piso y encenderse con la llama piloto del aparato o con los arcos eléctricos (descargas visibles semejantes a relámpagos) de los interruptores eléctricos y provocar un incendio.

**Conecte los aparatos directamente al generador. O use un cable muy resistente para exteriores** cuya capacidad (en vatios o amperios) sea al menos igual a la suma de las cargas de los aparatos conectados. Compruebe que no hay cortes ni roturas a lo largo de todo el cable y que el enchufe tiene las tres patas, en especial la de puesta a tierra. Nunca intente dar energía a la red eléctrica de la casa conectando el generador a un enchufe de pared (práctica conocida como "retroalimentación"). Esta práctica es muy peligrosa por el riesgo de electrocución para los trabajadores de la compañía eléctrica y los vecinos que conectan con el mismo transformador de servicio público. Además, no todos los dispositivos de protección incorporados del hogar lo detectan.

**Para el futuro**

El único método recomendado para conectar un generador a la red eléctrica de una casa es que un electricista acreditado instale un conmutador de transferencia. Este conmutador debe ser instalado con arreglo al *National Electrical Code*® publicado por la NFPA, y todos los códigos eléctricos estatales y locales aplicables. Llame a un electricista acreditado o pregunte a su compañía eléctrica si pueden instalarle el equipo adecuado.

En caso de interrupciones en el suministro de electricidad, los generadores fijos instalados de forma permanente son más adecuados para proporcionar energía de reserva al hogar. Incluso un generador portátil debidamente conectado puede sobrecargarse. Esto podría sobrecalentar o sobrecargar los componentes del generador y hacer que funcione mal. Lea con cuidado las instrucciones incluidas con el generador para asegurarse de que lo utiliza dentro de sus limitaciones de potencia.

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Información elaborada por la Cruz Roja Americana, con el asesoramiento técnico de la Asociación Nacional de Protección contra Incendios (NFPA) –que publica el Código Eléctrico Nacional (*National Electric Code*®)– y de la Comisión para la Seguridad de los Productos de Consumo de los Estados Unidos (CSPC).

Revisado y actualizado en septiembre de 2004.

# TAB X

Source: Gas Appliance Manufacturer's Association, Water Heater Division
*Consumer Safety Awareness Campaign: 1994 Follow-Up Report*
Prepared by Loran Nordgren & Co.

## EDUCATION PROGRAM

### Flammable Vapors School Program

The education program was developed for children in Kindergarten through eighth grade to help students recognize what flammable liquids are, why they are dangerous and how to use and store them properly. In addition to being technically reviewed by the **National Fire Protection Association**, this year's program has been formally endorsed by the **U.S. Consumer Product Safety Commission**. The Daredevil vs. Vapora Comic Book received the 1993 Parents' Choice Award, recognizing it as a valuable educational tool. As a result, the Parents' Choice seal appeared on the inside front cover of the comic books.

On March 11th, the educator's kit was sent to a new list of 80,000 K-8 teachers, a list representing one teacher in every grade and middle school in the country. An ad describing the program ran in Learning '94 and Creative Classroom. The ad included a coupon teachers could complete and return and a toll-free number to receive a copy of the program. This year, **13,605 educators** requested the educator's kit, which includes:

- 20-page Sparky/Daredevil booklet with copymasters
- Sparky/Daredevil classroom poster
- "Daredevil vs. Vapora" comic book
- "Step Up To Safety With Sparky" Activity Book
- Home Activity Guide with Vapora stickers
- Student Kit order form
- Evaluation form

On April 18th, the educator's kit was sent to 32,131 Fire Chiefs nationwide. Teachers and fire chiefs who received the kit could use the order form or call the toll-free number to request "student kits", with quantities of comic books, Sparky Activity books and Home Activity Guides. This year, we had the following response:

- **13,295 teachers requested free student kits. That's a 15% response rate. Each teacher requested an average of 3 kits, enough materials for 1.2 million students.**

- **1486 fire departments requested free student kits.**

The kits contained the following materials:

- K-3 Kit: 30 "Step Up to Safety With Sparky" and 30 Home Activity Guides.
- 4-8 Kits: 30 "Daredevil vs. Vapora" comics and 30 Home Activity Guides.

# TAB Y

U.S. CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, D.C. 20207

February 13, 2006

Subj: CPSC staff comments on UL's draft Outline of Investigation, 2201 *Portable Engine-Generator Assemblies*

Ref: (a) Draft 2201 *Portable Engine-Generator Assemblies*, Issue number 1
(b) UL's minutes of the STP meeting held on May 4, 2005 at UL's Northbrook Office, CSDS document 2201_1_20050527.pdf

The items below represent the U.S. Consumer Product Safety Commission (CPSC) staff's comments regarding UL's Outline of Investigation, ref (a). Please note that these comments were prepared by the CPSC staff, have not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

CPSC staff continues to advocate the development of performance provisions in a UL portable generator standard that would prevent dangerous levels of CO exposure to consumers under foreseeable conditions. Staff will continue to explore methods by which this could be practically and effectively accomplished. In the short term, the staff supports the UL 2201 Outline of Investigation and has prepared the following recommended revisions to the draft:

- In section 1.1, the carbon monoxide (CO) poisoning hazard should be included in the list of hazards.

- The terminology "OUTDOOR-USE UNITS," which appears in section 6.1.2.3 and elsewhere throughout the Outline of Investigation (OOI), is misleading since there are currently no portable generators that are safe for indoor use. Staff suggests replacing "OUTDOOR-USE UNITS" throughout the OOI to "RAINPROOF UNITS OR RAINTIGHT UNITS"

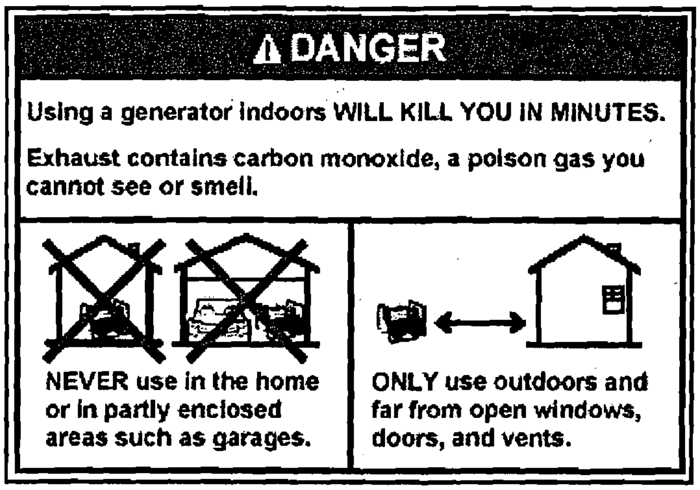
- Replace the existing section 18.4.1 with the following:

18.4.1 This test only applies to tanks exposed to sunlight while mounted in the normal configuration inside the product. It also applies to non-metallic enclosures of raintight units and rainproof units, per section 42.6.

- Replace sections 39.3.1 through 39.3.4 and 39.3.6 with the following:

39.3.1 The CO poisoning hazard label illustrated in Figure 39.4 shall be used on the product.

Figure 39.4 On-product carbon monoxide poisoning hazard label




A different representation of the generator may be substituted for accuracy if consumers are likely to recognize it as the generator to which this label is affixed.

a.) The signal word "DANGER" shall be in letters not less than 0.15 inch (3.8 mm) high. The remaining text shall be in type whose uppercase letters are not less than 0.1 inch (2.5 mm) high.

b.) The signal word "DANGER" shall appear in white letters on a safety red background.

The safety alert symbol  shall appear immediately before and next to the signal word and be no smaller than the height of the signal word with the base of the triangle on the same horizontal line as the base of the signal word. The solid portion of the triangle (within the lines of the triangle, around the exclamation mark) shall be white and the exclamation mark shall be safety red. The prohibition "X"s shall be safety red.

c.) The on-product hazard label shown in Figure 39.4 shall be located:
   1) On a part of the portable generator that, if removed, would impair the operation of the generator assembly, and
   2) On a location that is prominent and conspicuous to an operator while performing at least two of the following actions:
      - Filling the fuel tank
      - Accessing the receptacle panel
      - Starting the engine

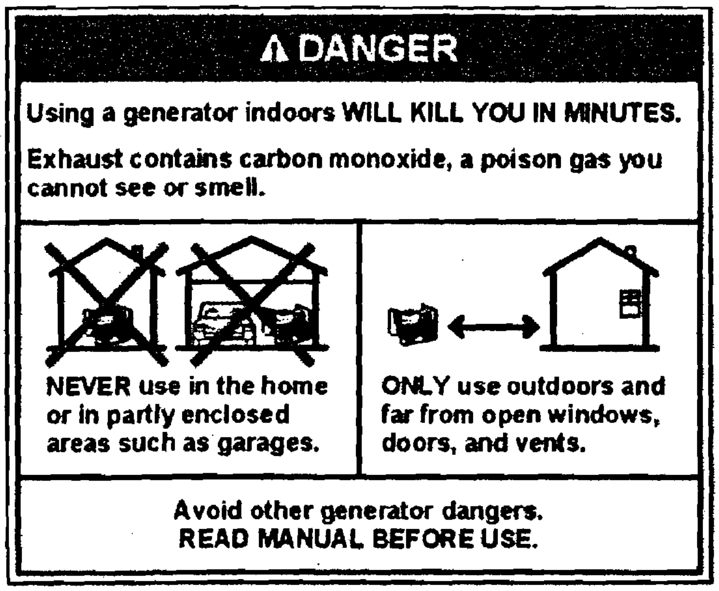
d.) The on-product hazard label shown in Figure 39.4 shall be designed to remain permanently affixed, intact, legible, and largely unfaded in the environment in which the product is expected to be operated and stored over the life of the product.

e.) For hazard labels other than the hazard label shown in Figure 39.4 that are used on the product,

1) Each shall be on one or more labels that are physically separate from that shown in Figure 39.4.
2) For those hazard labels using the signal word "WARNING" or "CAUTION", the signal word shall be in letters not less than 0.12 inch (3.0 mm) high and not greater than that used for "DANGER." The remaining text shall be in type whose uppercase letters are not less than 0.08 inch (2.0 mm) high and not greater than that used in the hazard label shown in Figure 39.4.

39.3.2 The CO poisoning hazard label shown in Figure 39.5 shall be affixed to the principal display panel(s) of the package, as well as the surface containing the top flaps of the package. The principal display panel(s) of the package is the portion(s) of the outer packaging that is designed to be most prominently displayed, shown, presented, or examined under conditions of retail sale. Any panel of the package that includes text in a language other than English shall also include a CO poisoning hazard label in that language. Alternate-language versions of this label may also appear on the top flaps of the package as long as they are physically separate from one another.

Figure 39.5. Carbon monoxide poisoning hazard label for package




A different representation of the generator may be substituted for accuracy if consumers are likely to recognize it as the generator contained within the packaging.

a.) The signal word "DANGER" shall be in letters not less than 0.15 inch (3.8 mm) high. The remaining text shall be in type whose uppercase letters are not less than 0.1 inch (2.5 mm) high.

b.) The signal word "DANGER" shall appear in white letters on a safety red background.

The safety alert symbol  shall appear immediately before and next to the signal word and be no smaller than the height of the signal word with the base of the triangle on the same horizontal line as the base of the signal word. The solid portion of the triangle (within the lines of the triangle, around the exclamation mark) shall be white and the exclamation mark shall be safety red. The prohibition "X"s shall be safety red.

c.) If one or more hazard labels other than the hazard label shown in Figure 39.5 is used on the package,
1) Each shall be on one or more labels that are physically separate from that shown in Figure 39.5.
2) None shall appear on the top flaps of the packaging.
3) For those hazard labels using the signal word "WARNING" or "CAUTION", the signal word shall be in letters not less than 0.12 inch (3.0 mm) high and not greater than that used for "DANGER." The remaining text shall be in type whose uppercase letters are not less than 0.08 inch (2.0 mm) high and not greater than that used in the hazard label shown in Figure 39.5.

- Staff recommends that subsections be added under 39.3.with specific on-product hazard label requirements for the electrocution hazard, burn hazard for hot surfaces, and fire hazard. Staff further recommends that these on-product hazard labels shall be on one or more labels that are separate from (not a part of) that specified in 39.3.2. For units that do not meet section 41 (RAINPROOF UNITS OR RAINTIGHT UNITS), the on-product electrocution hazard label shall include the following or equivalent text: "Do not use this product when it is wet outside."

- Staff needs clarification on section 39.3.5. The current wording in this section implies that conditions exist under which GFCI protection would not be required; however, section 16.1.1 requires GFCIs on all output circuits without exception.

- Replace sections 40.1.1 through 40.1.4 with the following sections:

40.1.1 The headings for the instruction manual shall be entirely in upper case letters not less than 3/16 inch (4.8 mm) high or emphasized to distinguish them from the rest of the text. The signal words for any cautionary text in the instructions shall be in letters not less than 0.12 inch (3.1 mm) high. The safety alert symbol ⚠ shall appear immediately before and next to the signal word and be no smaller than the height of the signal word with the base of the triangle on the same horizontal line as the base of the signal word. The remaining text of the instructions shall be in type whose uppercase letters are not less than 0.08 inch (2.0 mm) high.

40.1.2 The instruction manual shall include step-by-step operating instructions. The first step in these operating instructions shall describe where to operate the generator and how to select an appropriate site. The first step in the operating instructions shall also include the following text, at a minimum:

**⚠ DANGER**

CARBON MONOXIDE

Using a generator indoors WILL KILL YOU IN MINUTES.

Generator exhaust contains high levels of carbon monoxide (CO), a poisonous gas you cannot see or smell. If you can smell the generator exhaust, you are breathing CO. But even if you cannot smell the exhaust, you could be breathing CO.

- NEVER use a generator inside homes, garages, crawlspaces, or other partly enclosed areas. Deadly levels of carbon monoxide can build up in these areas. Using a fan or opening windows and doors does NOT supply enough fresh air.
- ONLY use a generator outdoors and far away from open windows, doors, and vents. These openings can pull in generator exhaust.

When you use a generator, always use a carbon monoxide alarm that is battery-powered or has an emergency battery backup.

If you start to feel sick, dizzy, or weak while using this generator, move to fresh air RIGHT AWAY. See a doctor. You could have carbon monoxide poisoning.

40.1.3 Unless the product meets the requirements in section 41 (RAINPROOF UNITS OR RAINTIGHT UNITS), the operating instructions shall, as a minimum, include a warning about the potential electrocution hazard associated with use of the product in wet conditions and shall state the following or equivalent: "Do not use this product when it is wet outside."

- Delete the existing section 40.1.4

- Replace the existing section 40.1.9.i) with the following text:

40.1.9.i) When GFCIs are provided, the following text shall be provided:

**⚠ WARNING**

GFCI cannot prevent electrocution unless generator is grounded.
Connect neutral supply of generator to an approved grounding electrode.
SPEAK TO AN ELECTRICIAN unless you are sure about approved grounding procedures.

- Add the following subsection to section 40.1:

40.1.10 The instruction manual shall contain the following text or equivalent:

If you must connect the generator to the house wiring to power appliances, have a qualified electrician install the appropriate equipment in accordance with local electrical codes. Or, check with your utility company to see if it can install an appropriate power transfer switch.

For power outages, permanently installed stationary generators are better suited for providing backup power to the home. Even a properly connected portable generator can become overloaded. This may result in overheating or stressing the generator components, possibly leading to a generator failure.

- Before section 41, replace "OUTDOOR-USE UNITS" with "RAINPROOF UNITS OR RAINTIGHT UNITS"

- Replace the words "an outdoor unit" in section 42.1 with the words "a rainproof unit or raintight unit".

- Replace the words "An outdoor-use" in section 43.1.1 with the words "A rainproof or raintight".

- Replace the words "an outdoor-use" in section 43.1.2 with the words "a rainproof or raintight".

- Replace the existing section 44.1 with the following sections 44.1 through 44.3:

44.1 For units that meet section 43.1.1 a), the primary display panel on the packaging of the generator shall include a label with letters not less than 0.1 inch (2.5 mm) high that states, "This product has a rainproof enclosure."

44.2 For units that meet section 43.1.1 b), the primary display panel on the packaging of the generator shall include a label with letters not less than 0.1 inch (2.5 mm) high that states, "This product has a raintight enclosure."

44.3 For units that do not meet section 43.1, the primary display panel on the packaging of the generator shall include a label with letters not less than 0.1 inch (2.5 mm) high that states "This product does not have a rainproof or raintight enclosure. Do not use this product when it is wet outside."

- The OOI currently does not have any requirements for cold impact tests for rainproof and raintight enclosures. On page 3 of UL's minutes of the STP meeting held on May 4, 2005 at UL's Northbrook Office, ref (b), it is stated that typical tests for outdoor requirements include cold impact tests, among other tests for which their requirements have been added to the OOI (i.e., tests for corrosion protection, rain for rainproof and raintight enclosures, UV or Xenon, accelerated aging, metallic coating thickness, and markings).

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

MEMORANDUM

DATE: May 26, 2006

TO: Janet L. Buyer, Project Manager, Generator Project,
Division of Combustion and Fire Sciences, Directorate for Engineering Sciences

THROUGH: Hugh M. McLaurin, Associate Executive Director,
Directorate for Engineering Sciences

Robert B. Ochsman, Ph.D., CPE, Director,
Division of Human Factors, Directorate for Engineering Sciences

FROM: Timothy P. Smith, Engineering Psychologist,
Division of Human Factors, Directorate for Engineering Sciences

SUBJECT: Product labels for generators to address carbon monoxide poisonings

## BACKGROUND

On October 12, 2005, Chairman Hal Stratton directed the staff of the U.S. Consumer Product Safety Commission (CPSC) to undertake a thorough review of the status of portable generator safety (Stratton, 2005). As part of this review, Chairman Stratton requested that the staff address the sufficiency of warning labels to address the carbon monoxide (CO) poisoning hazard posed by portable generators that are used within or near residences.

Prior to Chairman Stratton's request, the staff from the CPSC Division of Human Factors had written two previous memoranda related to CO poisonings, product labels, and engine-driven tools such as portable generators. One memorandum, from 2002, discussed the potential effectiveness of product labels and instruction manuals in addressing the carbon monoxide (CO) poisoning hazard associated with engine-driven tools and identified changes that might improve their effectiveness (Smith, 2002). The following year, the Human Factors staff proposed specific recommendations for warning language to accompany generators and other engine-driven tools (Smith, 2003). The current memorandum summarizes the Human Factors staff's new recommendations for a product label to be affixed to portable generators to address the CO poisoning hazard.[1] The staff included this label in its comments to Underwriters Laboratories (UL) for its Outline of Investigation, which was published in April 2006.

[1] These comments are those of the CPSC staff and have not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

## DISCUSSION

The product label recommended by the Human Factors staff appears in Figure 1. A discussion of the reasoning behind the content and formatting of the label, to the extent that it differs from what was recommended in the 2003 Smith memorandum, follows.

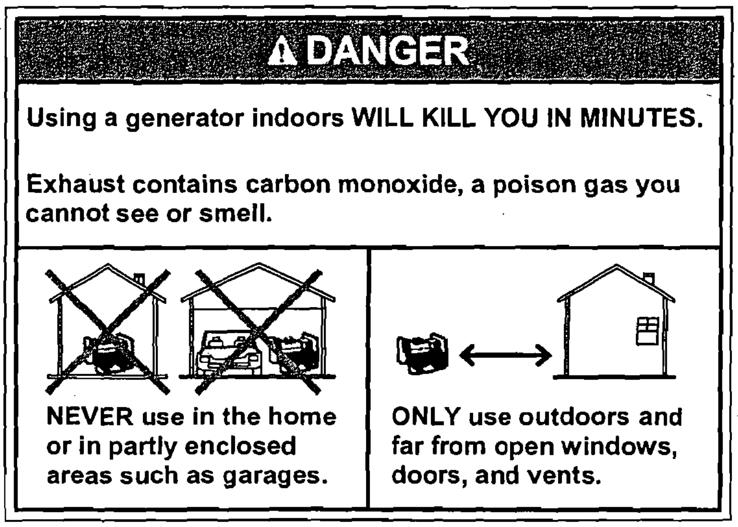



FIGURE 1. Recommended product label.

### THE HAZARD AND ITS CONSEQUENCES

The label originally recommended by the Human Factors staff (see Figure 2) was designed so it could also be applied to engine-driven tools other than generators (Smith, 2003). The wording of the label, therefore, was intentionally written in a more general or generic form. The new staff-recommended label is intended for generators only and, therefore, specifically identifies generators within the label. The Human Factors staff recommends that the product label include a description not just of the hazard (CO), but of the primary hazard pattern associated with CO-poisoning deaths. Both the staff's original label (Figure 2) and the label prepared by the UL STP as of December 2005 (Figure 3) identify the immediate hazard of CO and its consequences, but fail to describe the usage pattern that often leads to death. The available incident data shows that

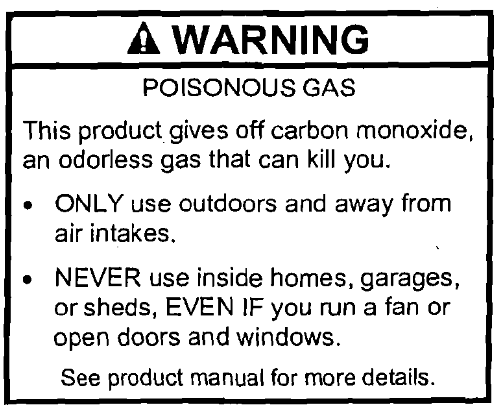



FIGURE 2. Original label from CPSC staff.

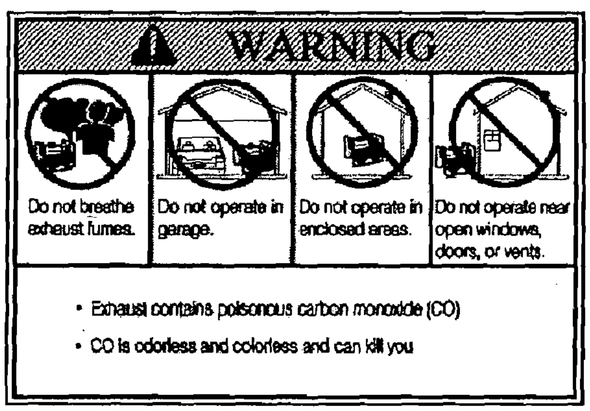



FIGURE 3. Label from UL STP.

indoor use of a generator is both the primary hazard pattern and is the hazard pattern most likely to lead to death. Although one might infer this from the hazard-avoidance recommendations within the label, starting the label with an explicit and succinct description of the hazard pattern would quickly provide consumers with a better understanding of the primary scenario that could lead to death. Research indicates that information about hazard scenarios affects consumers' risk judgments (Hendrickx, Vlek, & Oppewal, 1989), so the Human Factors staff believes that including this information would be highly beneficial.

The Human Factors staff also recommends that the label emphasize the imminence of the hazard. This piece of information is often lacking in CO-poisoning labels and is unlikely to be obvious to consumers. Additionally, consumers are more likely to comply with a warning about an imminent hazard since imminence tends to increase the perceived threat associated with a hazard (Gass & Seiter, 1999). The phrase "in minutes" should provide consumers with a better understanding of the speed with which incapacitation can occur.

Lastly, the staff recommends the use of the phrase "you cannot see or smell" rather than terms such as "odorless" and "colorless," which may be less familiar and understandable to some consumers. The term "colorless," in particular, could be misinterpreted as meaning that it is lacking a color other than that usually associated with exhaust or smoke. The phrase "you cannot see" is less likely to lead to critical confusion.

HAZARD AVOIDANCE

In its original proposal, the Human Factors staff recommended identifying in the label specific locations where a generator should not be used: homes, garages, and sheds (Smith, 2003). The label prepared by the UL STP as of December 2005 specifically warned against the use of generator in a garage, but did not identify other locations; it did, however, warn against the use of a generator in "enclosed areas." The Human Factors staff believes that this portion of the STP label is inadequate because it implies that a generator is only hazardous when used within a *fully* enclosed area or garage. The staff does agree, however, that the use of a more wide-reaching phrase such as "partly enclosed" could be useful in broadening the perceived range of potentially dangerous areas in which to operate a generator. The staff, therefore, recommends that the label warn specifically against use in the home and in garages, since these are known places in which consumers use generators, but that the label also refer to partly enclosed areas, as in "NEVER use in the home or in partly enclosed areas such as garages." The accompanying pictograms (see Figure 1) are based on the pictograms developed by the UL STP. Research shows that labels with pictograms tend to capture a consumer's attention more readily than a label without pictograms (Wogalter & Laughery, 2005; Wogalter & Leonard, 1999).

The Human Factors staff recommends that the pictograms use prohibition "X"s rather than circle-slash prohibition symbols. Both the circle-slash and "X" symbols are commonly recognized as conveying the prohibition concept (Dreyfuss, 1972; Wogalter & Leonard, 1999), and the ANSI Z535 series of standards generally recommends the use of a circle-slash symbol. However, the results of charcoal-pictogram testing previously performed for the CPSC found that some non-English-reading consumers did not understand the meaning of the circle-slash symbol but did understand the meaning of prohibition "X" symbols (Requirements for Labeling of Retail Containers of Charcoal, 1996). Additionally, there is no evidence that English-reading consumers would have difficulty understanding the meaning of a prohibition "X" symbol (Freeman & Wogalter, 2001). Thus, to improve the likelihood of comprehension by all consumers, the staff prefers the use of "X" symbols to convey prohibition except in cases in which a circle-slash symbol would render the prohibited act more understandable; for example, because it does not cover or obscure critical details of the underlying pictogram as much as an "X" symbol. In keeping with ANSI Z535.4 – 2002, the staff recommends that the "X" symbol be in safety red.

As before (Smith, 2003), the Human Factors staff continues to recommend that the CO poisoning label include a prescriptive, or positive action that consumers can take to avoid the hazard rather than focusing exclusively on prohibited behaviors, or what consumers should *not* do. This is consistent with the requirements of ANSI Z535.4 – 2002, and warning design guidelines commonly recommend that hazard-avoidance statements explicitly describe appropriate actions to be taken (for example; Wogalter, Conzola, & Smith-Jackson, 2002; Wogalter and Laughery, 2005). More importantly, a warning that focuses exclusively on prohibited behaviors forces the consumer to infer the appropriate behavior from what they are told not to do. Not only are messages that "fill in the blanks" more persuasive than messages that do not (Stiff & Mongeau, 2003), but forcing consumers to infer the appropriate behavior could result in consumers using the generator in unanticipated ways that, while not specifically prohibited in the label, still expose consumers to the hazard. The staff, therefore, recommends that consumers be told to use the generator outdoors only and far from open windows, doors, and vents.

The pictogram that accompanies this message (see Figure 1) is based on the other pictograms in the label, but has been designed to show the concept of keeping the generator away from the home; the use of a double arrow to indicate keeping a safe distance is consistent with ANSI Z535.3 – 2002. The UL STP label, in contrast, tells consumers to not operate the generator near open windows, doors, and vents, and includes a pictogram of a generator near the home with a prohibition symbol over the generator and home (see Figure 3). The danger of the UL STP pictogram is that someone who is rushed or is not English-literate could easily misinterpret the pictogram as meaning that the generator should not be used outside, which is precisely opposite the desired behavior.

Smith (2003) originally suggested that manufacturers consider the use of the hazardous gas/vapors pictogram, which shows a profile view of a person breathing poisonous gas (see Figure 4), but expressed reservations about the use of this pictogram since the gas in the pictogram is visible and carbon monoxide is not. The Human Factors staff continues to be concerned about this possibility and, because other pictograms have been developed that convey the desired information, does not recommend the use of this pictogram in the label. The UL STP label includes a version of this pictogram, and raises another potential problem with its use. The hazardous gas pictogram is commonly used alone, yet the modified version used in the STP label includes an overlying prohibition symbol (see Figure 3). Although the

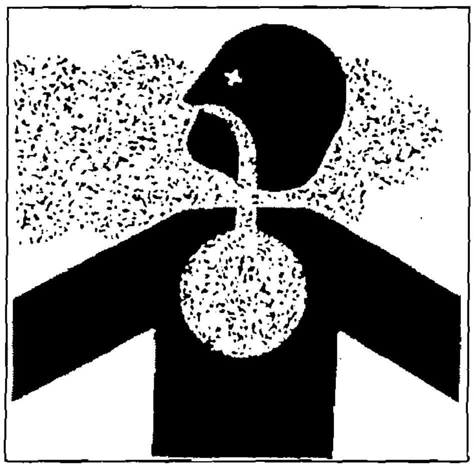


FIGURE 4. Hazardous gas/vapors pictogram.

hazardous gas pictogram may be understood by many consumers, it is unclear how one with an overlying prohibition symbol would be understood. Those who are familiar with the hazardous gas pictogram may have special difficulties due to negative transfer (Leonard, Otani, & Wogalter, 1999). For example, these consumers may be critically confused by the combined pictogram and prohibition symbol since the combination, by definition, should convey the opposite message as the pictogram without an overlying prohibition symbol.

### HAZARD SEVERITY

The staff originally recommended that the label use the signal word WARNING (Smith, 2003), but now recommends the use of the signal word DANGER. Although the presence of carbon monoxide in generator exhaust, on its own, could lead to death or serious injury, indoor use of generators—the hazard scenario specifically identified in the label—would almost certainly result in death or serious injury. The key issue, therefore, is the hazard scenario or situation identified in the label, not the hazard itself. This is consistent with the process through which one should select an appropriate signal word. For example, ANSI Z535.4 – 2002 states that product safety labels are classified using DANGER, WARNING, and CAUTION based on the relative seriousness of the "hazard *situation*" (Section 5.1, emphasis mine), and defines DANGER as an imminently "hazardous *situation* which, if not avoided, will result in death or serious injury" (Section 4.13.1, emphasis mine). The staff has also found that some generator manufacturers are already using DANGER on CO-poisoning labels for generators.

In keeping with the switch from WARNING to DANGER, the Human Factors staff also recommends that the signal word panel be changed from black text on an orange background to white text on a red background. This change is consistent with the colors recommended for DANGER by ANSI Z535.4 – 2002, and red is commonly viewed as indicating a more hazardous situation than orange or yellow (Leonard, Otani, & Wogalter, 1999). Some generator manufacturers are already using red rather than orange even when accompanied by the signal word "WARNING," and using red will allow generator manufacturers to create the labeling using only three colors (white, black, and red) rather than four (white, black, orange, and red for the prohibition "X" symbols).

## CONCLUSIONS

The Human Factors staff recommends the use of the label shown in Figure 1 to address the CO poisoning hazard associated with generators. The rationale behind the recommended label is described in detail within the *Discussion*, above.

## REFERENCES

*American National Standard for product safety signs and labels* (ANSI Z535.4 – 2002). (2002). Rosslyn, VA: National Electrical Manufacturers Association.

*American National Standard criteria for safety symbols* (ANSI Z535.3 – 2002). (2002). Rosslyn, VA: National Electrical Manufacturers Association.

Dreyfuss, H. (1972). *Symbol sourcebook: An authoritative guide to international graphic symbols*. New York: McGraw-Hill. 26.

Freeman, K., & Wogalter, M.S. (2001). Evaluation of pictorial symbols to warn computer keyboard users about carpal tunnel syndrome (CTS). *Proceedings of the Human Factors and Ergonomics Society 45th annual meeting, 45*, 1468–1472.

Gass, R.H., & Seiter, J.S. (1999). *Persuasion, social influence, and compliance gaining*. Boston: Allyn & Bacon.

Hendrickx, L., Vlek,C., & Oppewal, H. (1989). Relative importance of scenario information and frequency information in the judgment of risk. *Acta Psychologica, 72*, 41–63.

Leonard, S.D., Otani, H., & Wogalter, M.S. (1999). Comprehension and memory. In M.S. Wogalter, D.M. DeJoy, & K.R. Laughery (Eds.), *Warnings and risk communication* (pp. 149–187). Philadelphia: Taylor & Francis.

Requirements for Labeling of Retail Containers of Charcoal, 61(87) Fed. Reg. 19818–19830 (1996) (to be codified at 16 C.F.R. § 1500).

Smith, T.P. (June 18, 2002). *Human Factors assessment for the small engine-driven tools project*. CPSC Memorandum to Janet L. Buyer, Project Manager, U.S. Consumer Product Safety Commission, Washington, DC.

Smith, T.P. (August 22, 2003). *Proposed warning language to accompany generators*. CPSC Memorandum to Janet L. Buyer, Project Manager, U.S. Consumer Product Safety Commission, Washington, DC.

Stiff, J.B., & Mongeau, P.A. (2003). *Persuasive communication* (2nd ed.). New York: Guilford.

Stratton, H. (October 12, 2005). *Review of portable generator safety*. CPSC Memorandum to Patricia Semple, Executive Director, U.S. Consumer Product Safety Commission, Washington, DC.

Wogalter, M.S., Conzola, V.C., & Smith-Jackson, T.L. (2002). Research-based guidelines for warning design and evaluation. *Applied Ergonomics, 33*, 219–230.

Wogalter, M.S., & Laughery, K.R. (2005). Effectiveness of consumer product warnings: Design and forensic considerations. In Y.I. Noy & W. Karwowski (Eds.), *Handbook of human factors in litigation* (Chapter 31). Boca Raton, FL: CRC Press.

Wogalter, M.S., & Leonard, S.D. (1999). Attention capture and maintenance. In M.S. Wogalter, D.M. DeJoy, & K.R. Laughery (Eds.), *Warnings and risk communication* (pp. 123–148). Philadelphia: Taylor & Francis.

**TAB Z**

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