



# **Portable Generators**

## **CPSC Staff Report**

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## **Portable Generators**

Portable generators are frequently used to provide electricity during temporary power outages or to remote locations. These generators use fuel-burning engines that emit poisonous carbon monoxide (CO) gas in their exhaust.

- CO Poisoning Deaths Associated with Portable Generators**

In 2003, for the second year in a row, CO poisoning deaths associated with portable generators reported to the U.S. Consumer Product Safety Commission (CPSC) doubled compared to numbers reported in 2001 and 2000. In 2003, CPSC had reports of 36 deaths from CO poisoning associated with portable generators. In 2002, there were 40 deaths reported. This was a 100% increase from the reported 18 deaths in 2001 and 20 deaths in 2000.

From 1990 through 2003, 228 CO poisoning deaths associated with portable generators were reported to CPSC.

About 40% of those deaths (89) occurred during the winter months. Almost 70% of the deaths occurred at a home. Of those that occurred at a home, the generators were often operated in basements/crawlspaces or in garages/enclosed carports. About 26% of fatal generator incidents involved more than one fatality.

Adults ages 25 and older accounted for about 80% of CO poisoning deaths associated with portable generators. The majority of the victims (72%) were male.

Virtually all of the deaths were preventable.

- CPSC Staff In-depth Investigations**

Out of the 228 deaths associated with portable generators, CPSC staff investigated 138 of those deaths to obtain more in-depth information. The following factors were requested in the investigations.

### Portable Generator Location

Of 100 deaths investigated where the location of the death was the home, 65 occurred when the generator was operated in the basement/crawl space or garage/enclosed carport.

Twenty investigated deaths included a reason as to why the generator was run indoors.

- The most common reason given for using the generator indoors was that the user feared someone might steal the generator (10 deaths).
- Other reasons for using the generator indoors included: if used outdoors, the cord that led to the home prevented outside access doors from closing (2 deaths); to muffle the

sound (2 deaths); didn't want the neighbors to know their electricity had been turned off (2 deaths); complaints of property owner (1 death); to fix the generator (1 death); did not think about operating it outside (1 death); and when the generator was run outside it would stall, so the user would operate it inside for some time and then put it back outside (1 death).

- There was not much information available as to whether a user was aware of the CO hazard associated with using the generator indoors.

#### Venting of Portable Generator

Twenty-five of the death investigations reported some attempt to vent the portable generator or provide ventilation to the area where the portable generator was operating. Of these, 19 investigated deaths reported an open window, an open door, an open garage door, or a combination of these.

The remainder of these included a variety of scenarios. In one investigated death, the generator was located in the garage; the garage car door was open until the generator was turned off. Then the garage door was closed. The deceased was found in the loft of the garage. Two investigated deaths were associated with a generator that was placed outside the home near an open window. Two investigated deaths were associated with a portable generator used on a boat, and the users attempted to vent the generator by modifying the exhaust system in place for an installed generator. In one investigated death, the generator was operated outdoors for some time; then it would stall and would be operated in the doorway for a period of time.

#### Size and Fuel of Portable Generator

The size of the generator and the fuel used with the generator were both examined. When the wattage rating of the generator was known (82 investigated deaths), the majority of the investigated deaths (33) involved generators in the 5 kW rating range.

All the generators, except one propane model, were powered by gasoline.

- **CPSC Staff Testing and Modeling Activities to Characterize the CO Poisoning Hazard Associated with Portable Generators**

Using two gasoline-powered portable generators representative of those typically owned by consumers, CPSC staff conducted special laboratory tests to determine the rate at which the generators produced CO.

The test results were used in conjunction with a computer model of a two-story house with a portable generator running in the basement to estimate the CO infiltration rate throughout the house. This data was then used in a health assessment model to estimate how quickly occupants in the modeled house would be incapacitated and possibly die from CO.

The health assessment model predicted the carboxyhemoglobin (COHb) level of an exposed individual. The COHb level is a measure of how much CO is absorbed in an exposed person's bloodstream. An approximate correlation between attainment of different COHb levels and symptoms in healthy adults is as follows:

- 20% to 30% COHb, considered to be the onset of serious concern, causes throbbing headache and mild nausea;
- 30% to 40% COHb causes severe headache, dizziness, nausea, vomiting, and cognitive impairment, making it unlikely the individual could remove himself from the environment;
- 40% to 50% COHb causes confusion, unconsciousness, coma, and possible death;
- 50% to 70% COHb causes coma, brain damage, seizures, and possible death;
- a level greater than 70% is typically fatal.

The relationship above is not absolute and there is overlap between symptom categories, particularly if the COHb level is sustained for a long duration.

Different scenarios were modeled. For example, when the portable generator was located and running in a home's basement, it was predicted that:

- Persons in the basement would reach a 40% COHb level in 29 minutes and a 60% COHb level in 40 minutes when the fan for the heating/ventilating/air conditioning system (HVAC) was not powered. With the HVAC fan on, these COHb levels would be attained in 40 and 62 minutes, respectively.
- Persons in a second floor bedroom would reach a 40% COHb level in 232 minutes and a 60% COHb level in 300 minutes when the HVAC was not powered. With the HVAC fan on, these COHb levels would be reached more quickly, in 146 and 201 minutes, respectively.

The projected CO levels exceeded 1200 ppm in over 90% of the different locations in the home that were modeled. This concentration is defined by the National Institute for Occupational Safety and Health (NIOSH) as the level that is "Immediately Dangerous to Life and Health" (IDLH).

The rapid development of potentially lethal CO exposures explains why victims are frequently found dead or severely poisoned within a few hours or from overnight exposures after being missed by family, friends, or co-workers.

COHb levels were provided for 86 of the 138 fatalities that were investigated by CPSC field staff. The majority of individuals (74 of the 86) with reported COHb levels had levels greater than 50% COHb.

- **Portable Generator Sales**

In preparation for Y2K, consumers purchased more than 400,000 portable generators in 1999.\* Annual sales dropped to about half that in the following years. CPSC staff estimates there are currently about one million portable generators in U.S. households.

Most consumers purchase light-duty, gasoline-powered portable generators. The most popular ones are 5 to 6 kW of output, accounting for about 52% of light-duty sales.\*

Consumer demand for generators may be attributed to power outages caused by weather-related disasters, power grid failures, and rolling blackouts. The possibility of outages related to security concerns and increased reliance on power for home-office functions also has been linked to portable generator demand.

\* (Source: Frost and Sullivan, *North American Portable Power Markets*)

- **CPSC Staff Actions**

CPSC staff has been involved in a number of important activities regarding portable generators. These include:

- Participating in an Underwriters Laboratories (UL) standards technical panel to develop a standard for portable generators (UL 2201).
- Participating in a UL working group to develop CO hazard warnings for product labels and for instruction and owners' manuals.
- Conducting portable generator testing and modeling activities to characterize the CO poisoning health hazard posed by consumer use of portable generators.
- Hosting a national forum at CPSC Headquarters on May 20, 2004 to develop new strategies to improve the safety of portable generators, particularly regarding the CO poisoning hazard. Those attending the forum included public health and safety officials, manufacturers, voluntary standards organizations, retailers, medical professionals, utility representatives, and consumer groups.
- Producing a video news release to be used to provide early warnings of the CO hazard associated with portable generators before anticipated severe weather.