CPSC Staff Recommendations to UL 2201 for Shutoff System Requirements and Staff's Investigations of Various Shutoff Concepts

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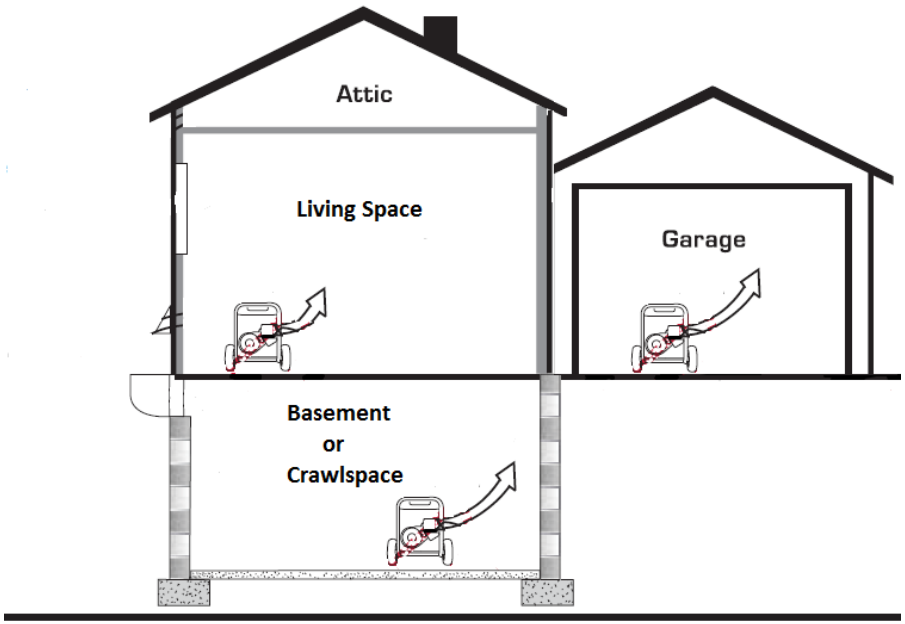
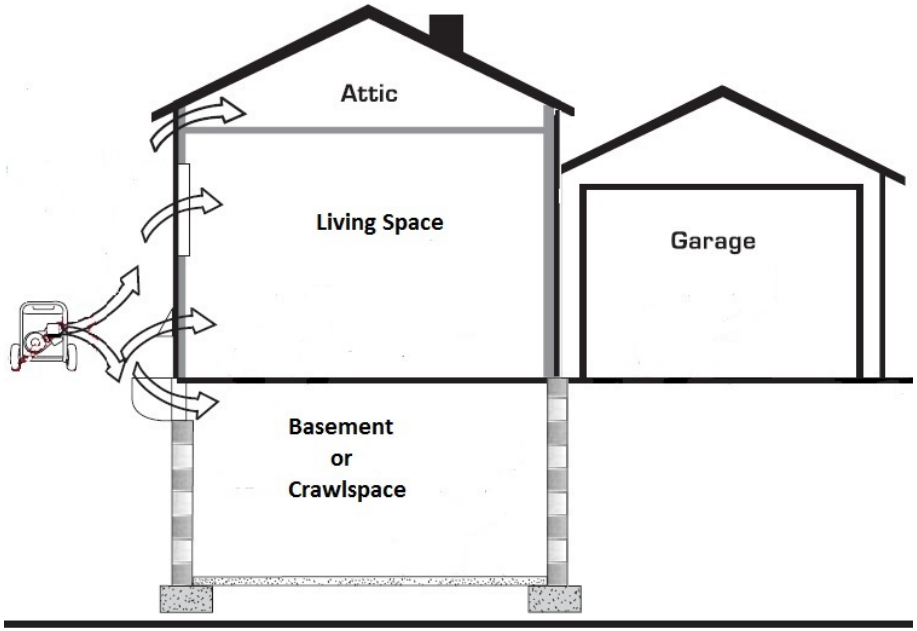
Recommendations If Generators Are Equipped with a Shutoff System

When operated indoors, shutoff must occur before exhaust creates unsafe CO exposure.



When operated outdoors, limit on CO emission rate needed for scenarios where exhaust infiltrates indoors.



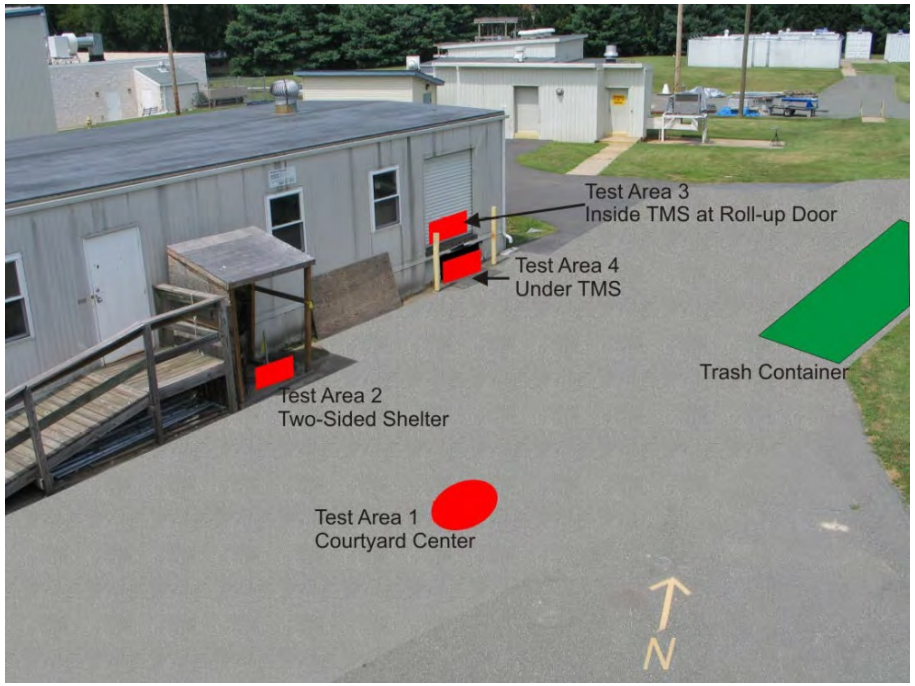
In addition, the shutoff system must :

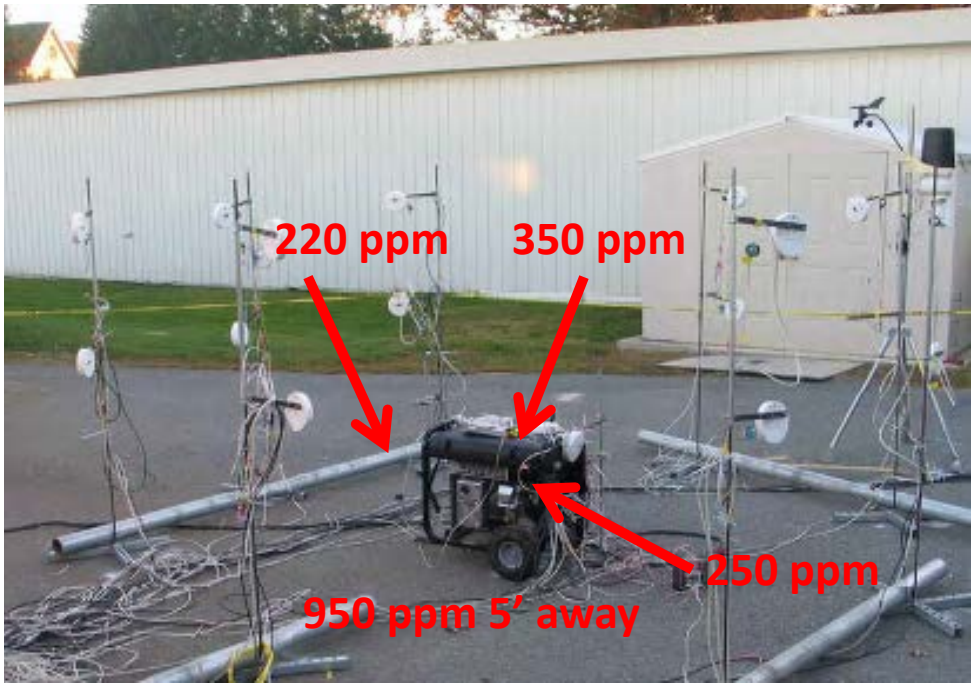
- include a supervisory circuit that prevents the generator from starting if shutoff system:
  - is bypassed due to consumer tampering, or
  - fails in some way (contaminated sensor, discharged battery, etc.)
- be durable and work throughout the generator's operational life without the need for calibration or service

Shutoff Concepts Investigated by CPSC Staff

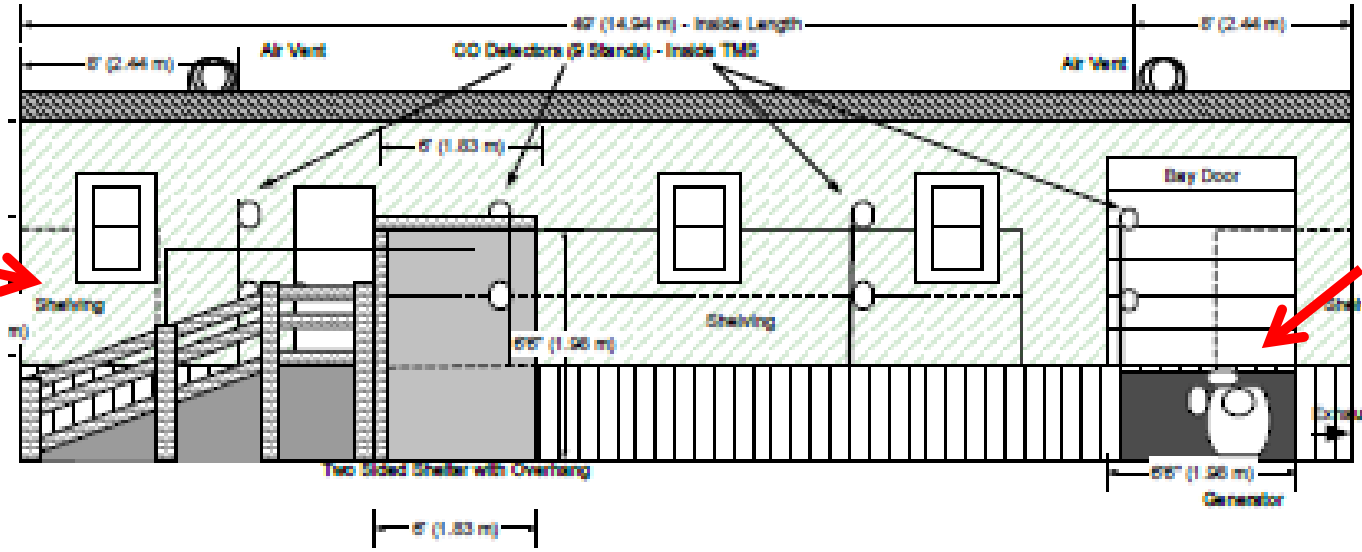
- CO sensing system mounted on generator
- Remotely located CO sensing system that communicates with generator; relies on user to place sensing unit in proper location
- GPS system mounted on generator; relies on poor signal strength to infer generator is located indoors
- Algorithm programmed into engine control unit (ECU) on prototype; relies on electronic fuel injection (EFI) system sensors to infer indoor operation

Generator-Mounted CO Sensing System



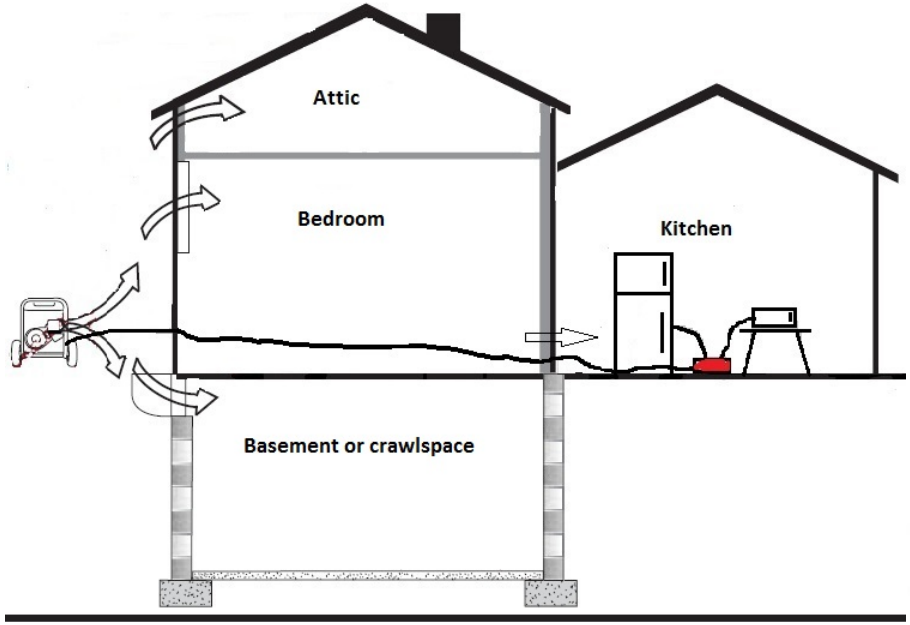


1000 ppm measured in this end of building before CO sensors mounted on generator shut it off

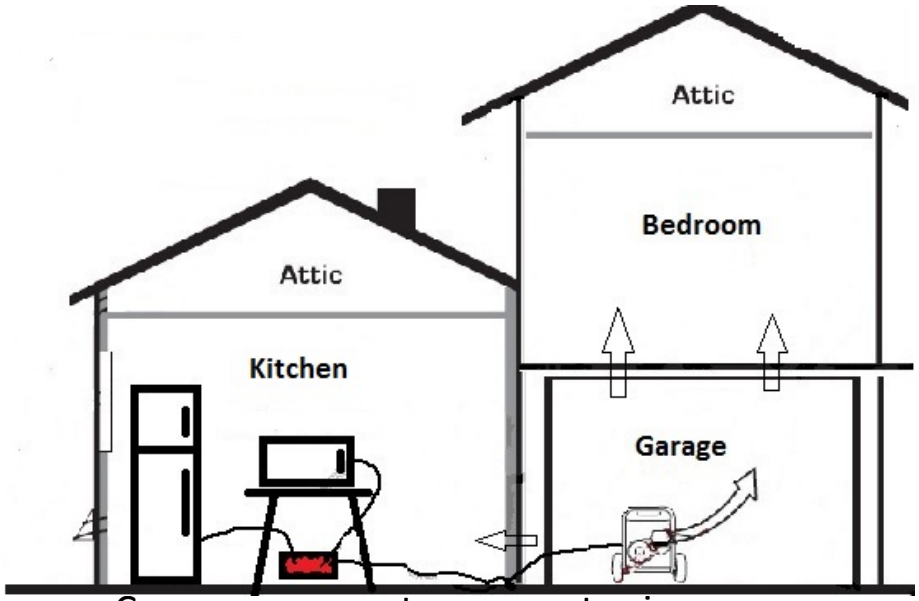


Generator operated inside - bay door closed

Remotely Located CO Sensors for Generator Shutoff System: Pitfalls of Relying on User to Find Best Location for CO Sensor



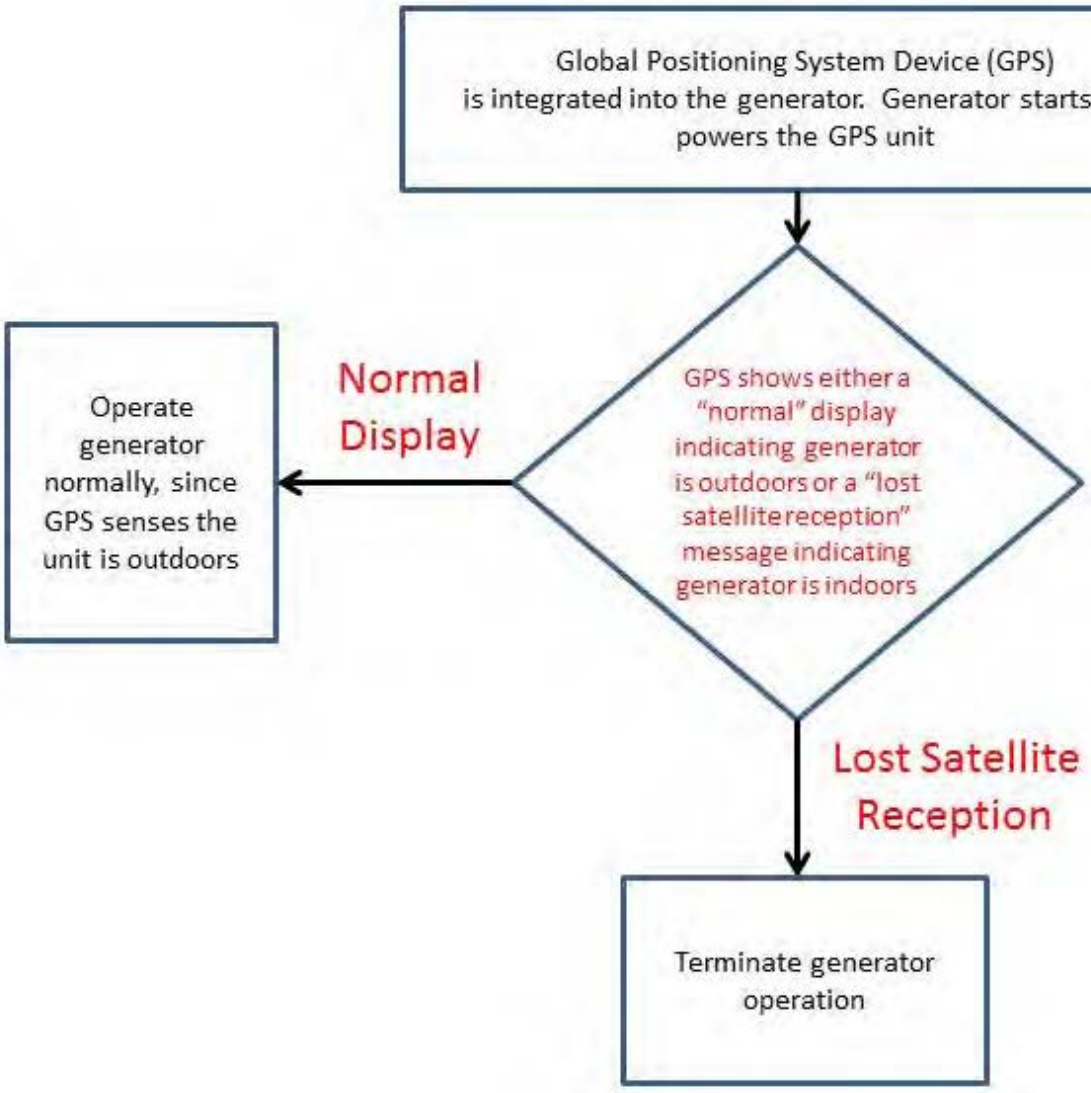
- Consumer operates generator outdoors.
- Exhaust infiltrates more quickly into rooms other than where consumer put the CO sensor.
- Danger exists for occupants of those other rooms.



- Consumer operates generator in garage.
- Exhaust infiltrates more quickly into rooms other than where consumer put the CO sensor.
- Danger exists for occupants of those other rooms.
- Consumer entering garage will walk into potentially lethal environment.
- To keep system from shutting off the generator, consumer could put the CO alarm in a drawer or outside a window.

Generator-Mounted Global Positioning System to Infer Generator Is Located Indoors

The Concept:



Generator-Mounted Global Positioning System to Infer Generator Is Located Indoors, continued

Home	Indoor Detection	Front Yard (Outdoor) Detection	Back Yard (Outdoor) Detection
Single -family detached home with 2-car garage	YES	YES	YES
Townhouse with 1-car garage	YES	YES	YES
Single-family detached home with 4-car garage	YES	**NO**	YES
Single-family detached home with 1-car garage	YES	YES	YES
Single-family, one level detached home with detached garage (2-car garage)	YES	YES	YES
Single-family detached home with 1-car garage	YES	YES	**NO**
Single-family, detached one-level home, no garage	YES	**NO**	**NO**

Algorithm Programmed into Prototype Generator's Engine Control Unit (ECU)

- University of Alabama (UA) tasked to develop and program into the fuel injection system's ECU an algorithm to sense when generator is operating in an enclosed space and automatically shut it off.
  - Specified no additional sensors beyond those already integral to the existing engine management system
- Two algorithms developed:
  - On first, supplementary testing conducted by CPSC staff and NIST found it unacceptable:
    - would occasionally shut the generator off when operated outdoors
    - under certain circumstances would not shut it off when operated indoors.
  - On second, in limited testing performed by UA, the generator:
    - shut off when operated indoors (7 tests)
    - did not shut off when operated outdoors (5 tests)

Limiting Engine's CO Emission Rate, Not Shutoff, Is Strategy Used to Address Risk of Acute CO Poisoning Hazard

- In 2002, EPA adopted a 4.4 g/kW-hr CO emission standard for engines that power equipment designed for use in enclosed spaces

- In 2008, EPA adopted a 5.0 g/kW-hr CO emission standard specifically for engines that power marine generators
  - EPA limit for all other small SI engines is 610 g/kW-hr