

# Carbon Monoxide Hazard from Generators



**13<sup>th</sup> Annual ICPHS0 Meeting and Training Symposium**

**May 10, 2006**

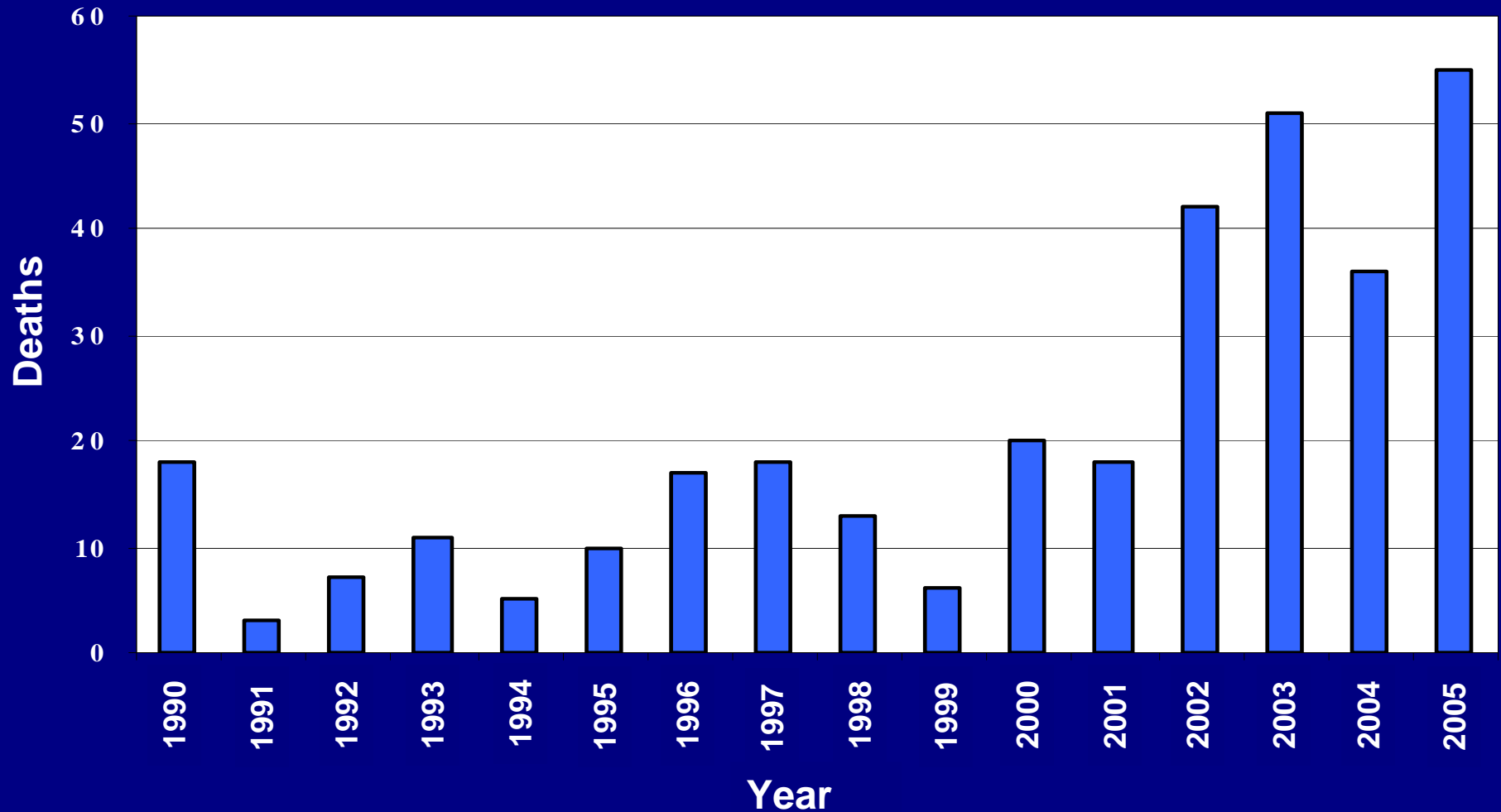
**Presented by Janet Buyer, Mechanical Engineer**

**Contributing team members: Christopher Brown, Patty Davis, Mary Donaldson,  
Robin Ingle, Sandy Inkster, Arthur Lee, Tim Smith, Don Switzer**

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



# Number of Non-Fire Carbon Monoxide Poisoning Deaths Associated with Generators Reported to CPSC By Year



For the years 1990 through 2003, these are the number of deaths in the CPSC databases as of 6/27/2005. For the years 2004 and 2005, these are the number of deaths in the CPSC databases as of 12/31/2005. The ICD-10 System was implemented in 1999.



# Description of Incident Data

In 137 fatal generator-related incidents that were investigated by CPSC staff\*, which involved 189 deaths, we learned 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 obtained in investigations of only 32 deaths.)
- In at least 5 deaths, it was reported that the generator was operated outside the home but near an open window, door, or vent.
- 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.
- Almost all of the generators were referred to as gas or gasoline generators.

\* Does not include any investigations conducted on deaths that occurred in 2005.



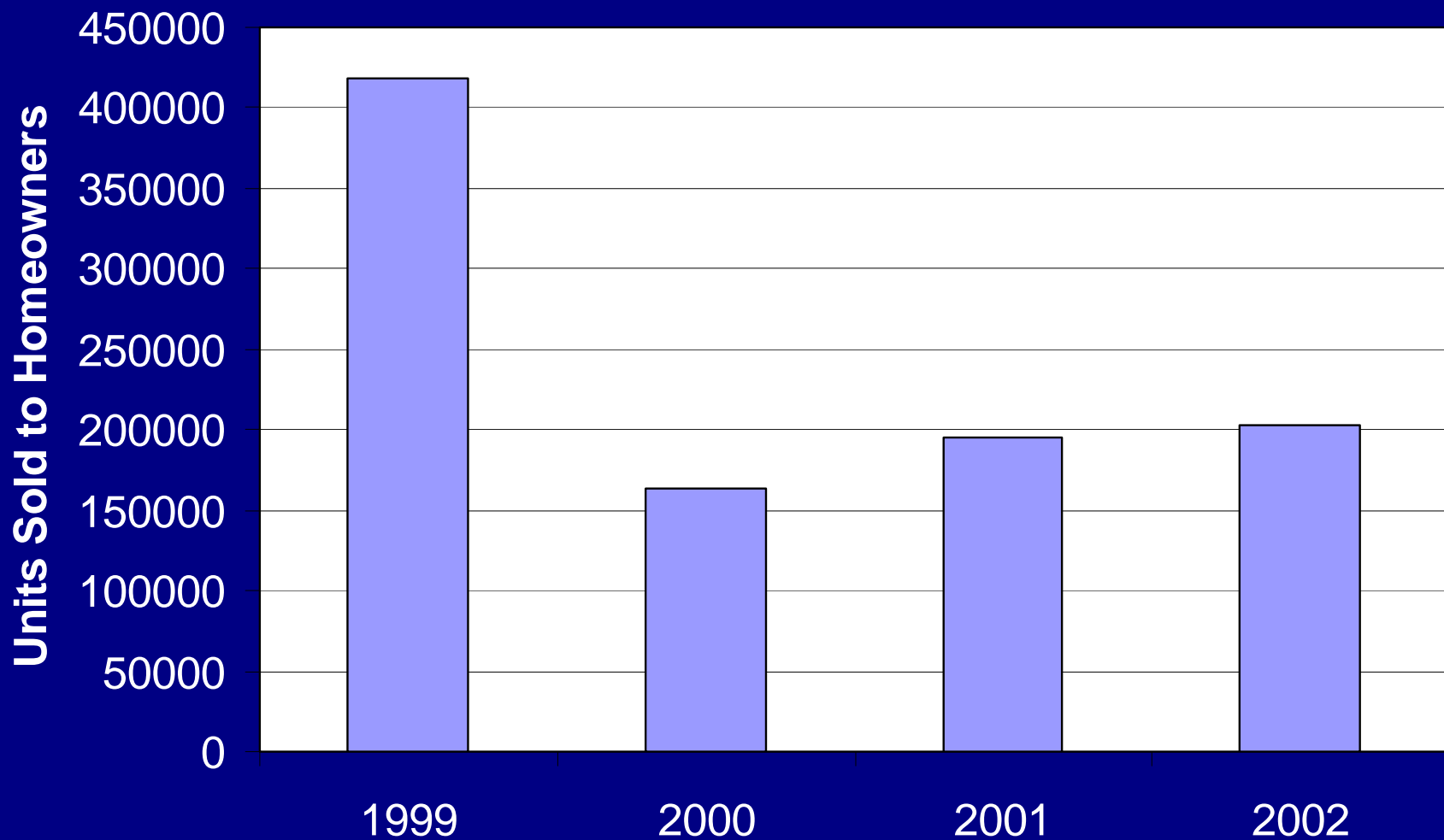
# Market Information

- Homeowners are largest end users of light duty (<15 kW) portable generators.
- CPSC staff estimates about 1 million portable generators in US households.
- More than half of light duty portable generators are sold through standard mass market channels (hardware stores, discount retailers, home centers).
- Most popular generators cost \$500-\$800.

**Sources:** Frost & Sullivan, *North American Portable Power Markets*  
CPSC Product Population Model  
*The Columbus Dispatch*, 4/5/99



## Estimated Homeowner Purchases of Light Duty Portable Generators, 1999-2002



Source: Frost & Sullivan, *North American Portable Power Markets*



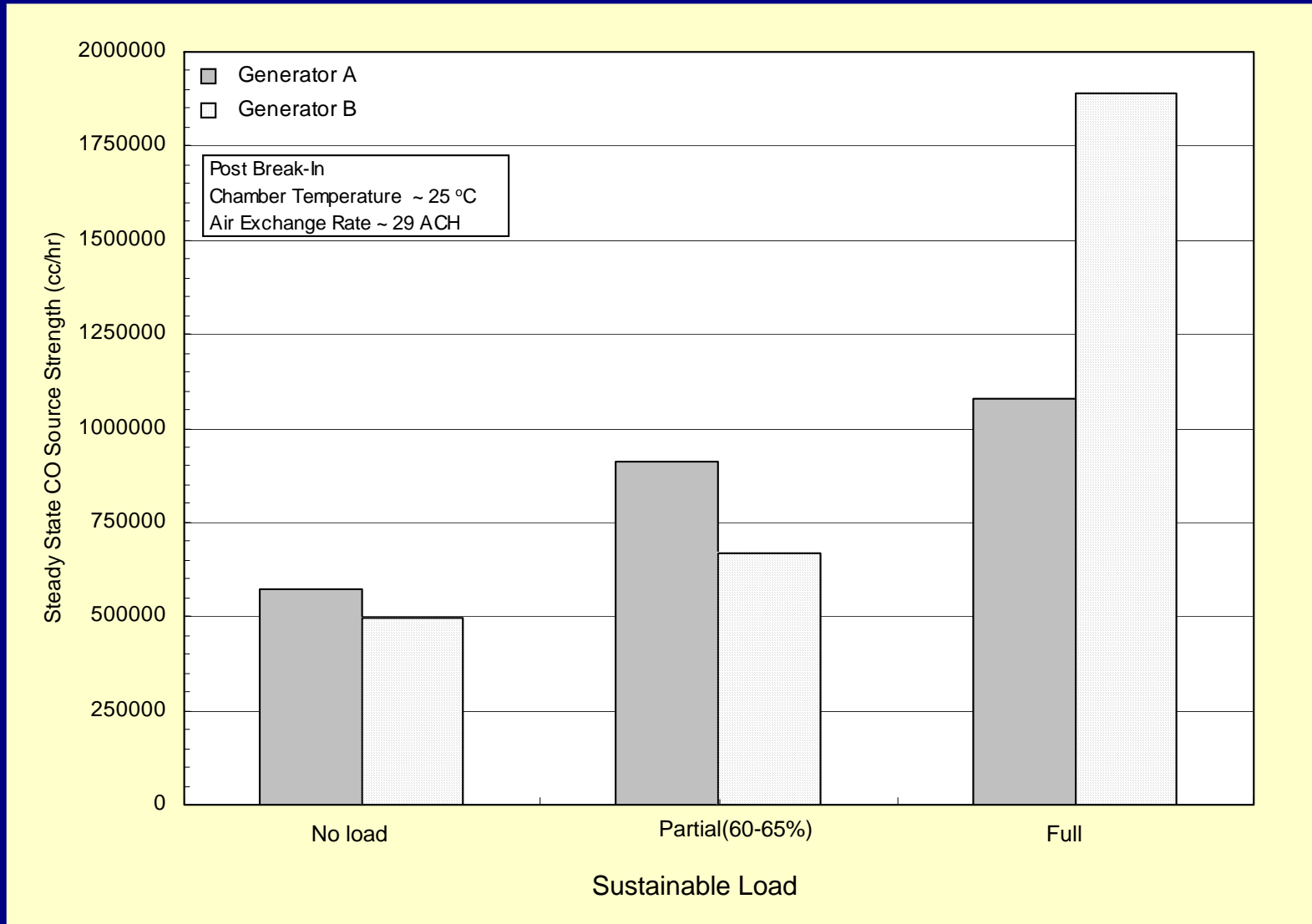
# Health Hazard Characterization

CPSC staff conducted testing and modeling 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, operating until it ran out of fuel.

- 1. Testing:** Experimentally-determined CO generation rates of two generators rated 8.5 kW surge, 5.5 kW continuous, 120/240V under different load and ambient conditions.  
Engine: 10 HP, gasoline, single-cylinder, overhead valve, air-cooled, 4-stroke  
Load - none, partial, full  
Ambient conditions – temperature, chamber air exchange rate
- 2. Modeling:** Using experimental data and EPA model of two-story house, estimated CO infiltration throughout house with generator running in the basement for 6 hours.  
Home: Single family home, 2 finished levels, basement, 750 ft<sup>2</sup> per level  
HVAC system – fan status on and off
- 3. Modeling:** Used modeled CO concentrations in house in conjunction with COHb models to estimate how quickly occupants would be incapacitated and possibly die.  
Occupant activity levels – resting and moderately active

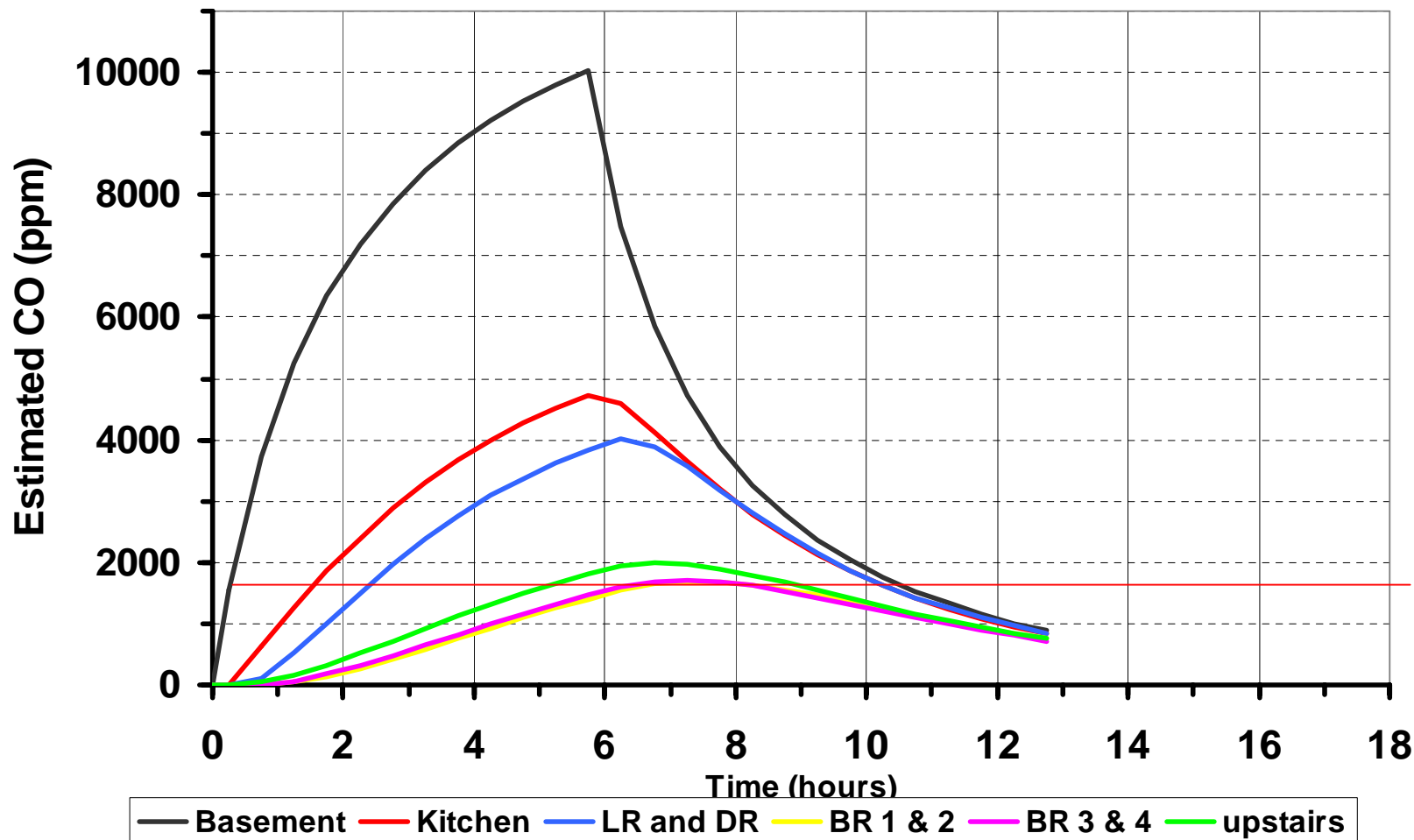


# Steady State CO Generation Rate Vs. Load



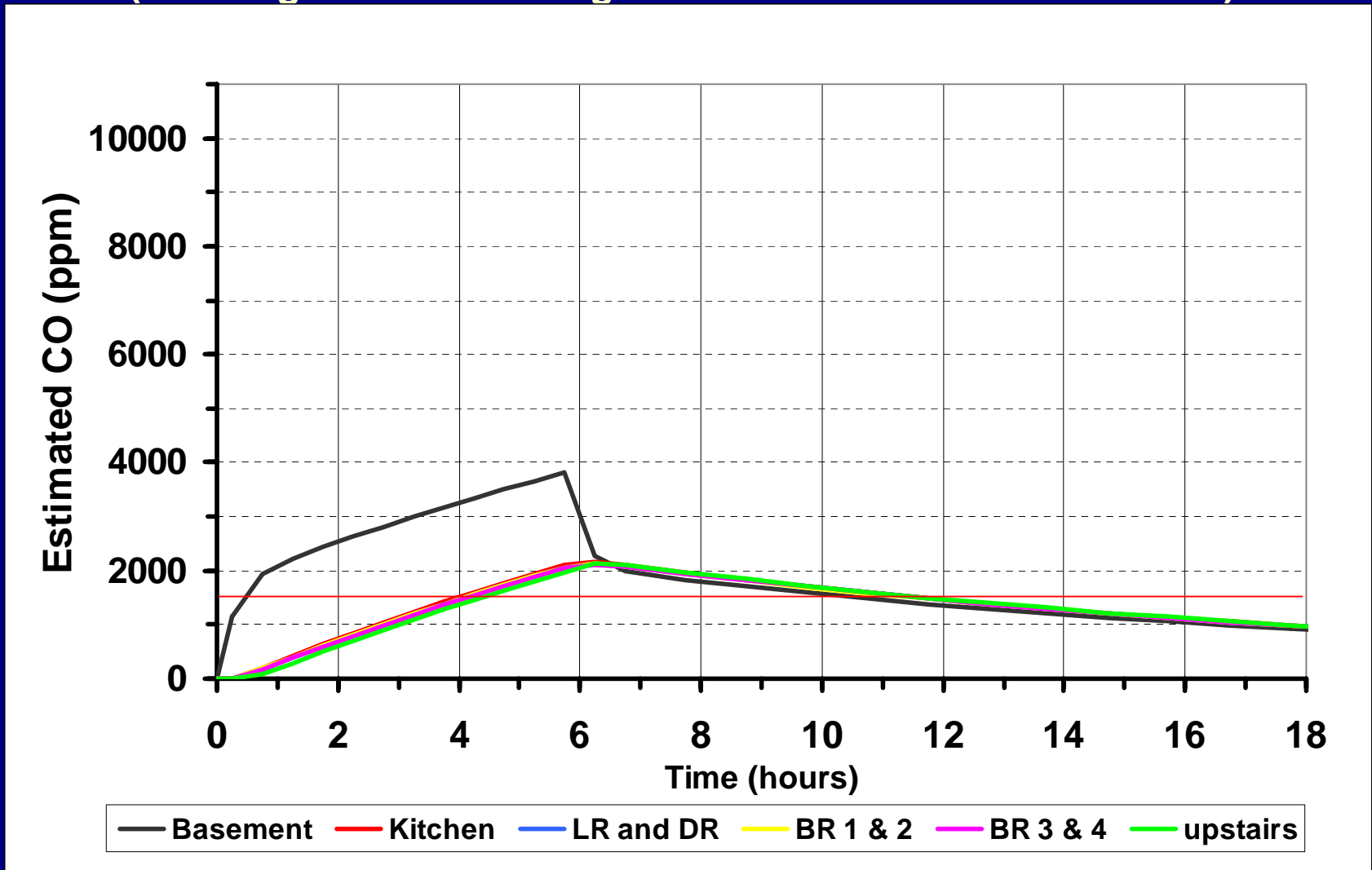
# CO Time Course Profiles In Home Model HVAC Fan Off

(5.5 kW generator running in basement for 6h with full load)

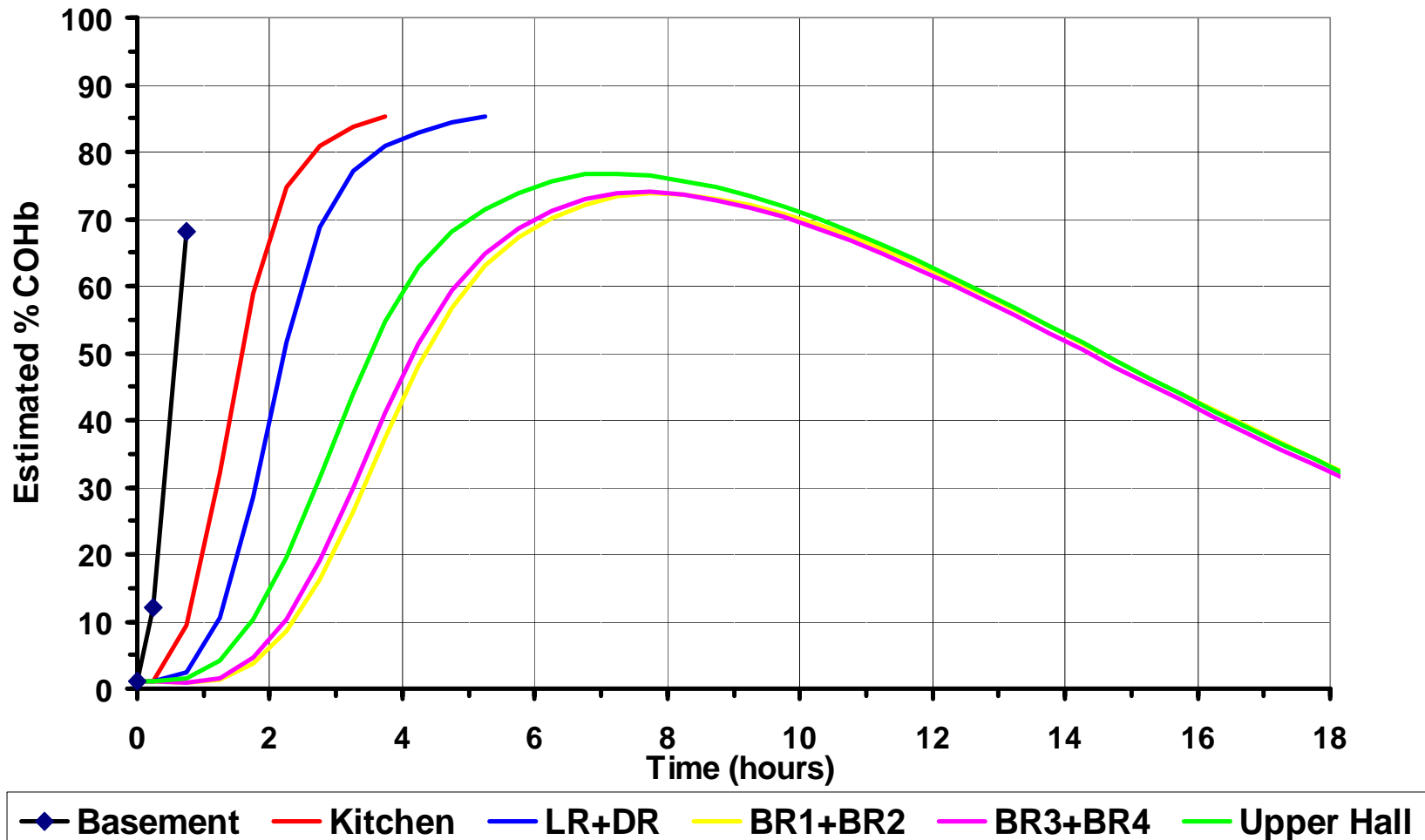


# CO Time Course Profiles In Home Model HVAC Fan On

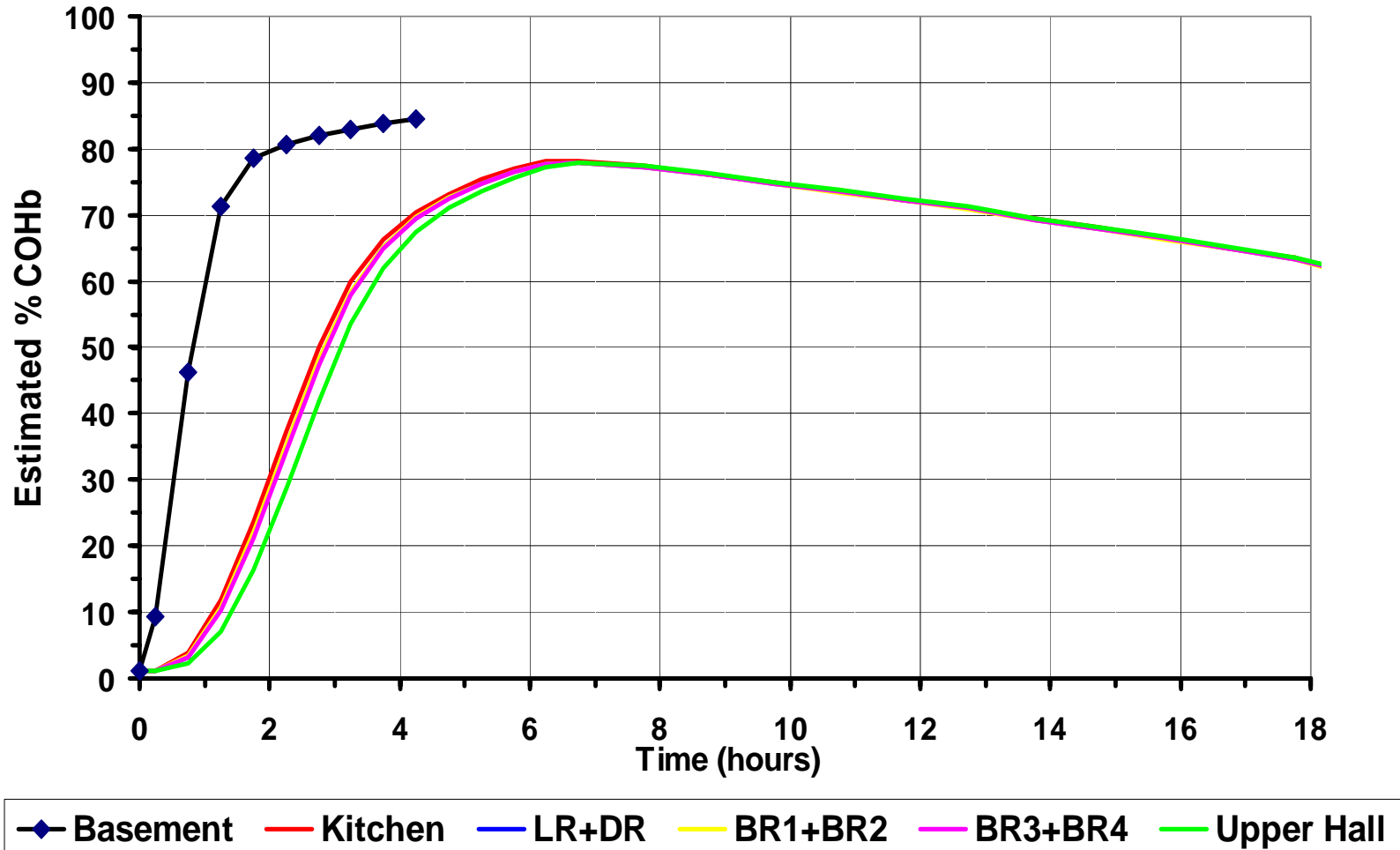
(5.5 kW generator running in basement for 6h with full load)



# Predicted % COHb Profiles for Moderately Active Individuals In Different Areas of Model Home: HVAC Fan Off (5.5 kW generator running in basement for 6h with full load)



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# Results of Modeling Studies

Worst Case Scenario Modeled : Full Load, Moderately Active Person

Basement : HVAC fan off (HVAC fan on)

- incapacitation at ~ 30 minutes (~ 40 minutes)
- death at ~ 40 minutes (~ 1 hour)

Upper Bedrooms: HVAC fan off (HVAC fan on)

- incapacitation at ~ 4 hours (~ 2 ½ hours)
- death at ~ 5 hours (~ 3 ½ hours)



# Recent CPSC Staff Activities

- Responding to Chairman's request for staff review of portable generator safety
- Participating in development of first U.S. voluntary standard for portable generators, UL 2201
- Made recommendations to UL on Outline of Investigation for portable generators, Subject 2201
- Demonstrating remote CO-sensing automatic shut off device concept
- Issued Request for Information (RFI) for technical solution to reduce engine CO emission rate
- Continuing outreach through Public Affairs and CPSC documents



# Review of Portable Generator Safety

- Feasibility of safety cut-offs
- Sufficiency of warning labels
- Performance requirements to reduce CO emissions
- Creation of an information and education campaign
- Potential benefits of a private sector consortium to develop a technical solution



# Participation in Development of UL 2201

- Non-voting member of STP which is drafting the first proposed edition of UL 2201, *Portable Engine-Generator Assemblies*.
- Staff has recommended requirements be developed that will address:
  - Consumer exposure to unsafe CO emissions
  - Safe outdoor use in wet conditions
  - Cautionary markings on product and packaging and in instruction manual
  - Satisfactory engine operability in icing conditions
- Draft standard addresses the CO hazard only through cautionary markings; staff considers this inadequate.
- STP consensus not yet achieved on draft standard.



# UL's Outline of Investigation Subject 2201

UL issued an Outline of Investigation, Subject 2201 on April 7, 2006.

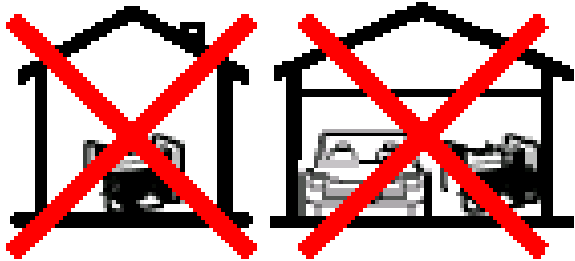
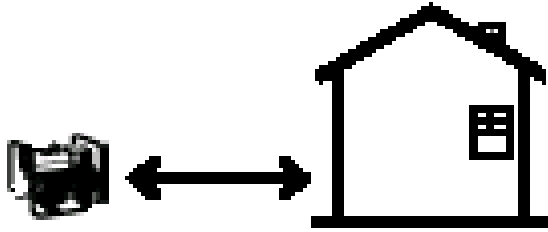
- This is not a consensus document.
- It establishes UL's certification requirements.
- UL sought and received staff's comments and recommendations.
- Subject 2201 includes requirements for
  - features that will permit safe use in wet conditions
  - warnings about CO poisoning on product and packaging and in instruction manual



# CPSC Staff's On-Product Label Recommendation and Requirement in UL's Subject 2201

**⚠ DANGER**

Using a generator indoors **WILL KILL YOU IN MINUTES.**  
Exhaust contains carbon monoxide, a poison gas you cannot see or smell.

 <p><b>NEVER</b> use in the home or in partly enclosed areas such as garages.</p>	 <p><b>ONLY</b> use outdoors and far from open windows, doors, and vents.</p>
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# Demonstration of Remote CO-Sensing Automatic Shut Off Device for Portable Generators

- Proof of concept demonstration that integrates a CO detection system with a portable generator.
- Utilizes wireless technology combined with residential CO alarm and off-the-shelf circuitry to provide an automatic shut off feature for portable generators.



# Request for Information (RFI) for Technical Solutions

The CPSC staff is interested in obtaining ideas, data, concepts, etc. that may lead to practical approaches to substantially reduce the tailpipe CO emissions from portable gasoline engine-powered generators to levels that could reduce the number of CO poisoning deaths and injuries.

- An aggressive tentative target of reducing current CO emissions by 90% using existing emission-abatement technologies that can be reapplied to small engines
- Parameters for determining technical feasibility:
  - amount of CO emissions reduction
  - effect on engine performance
  - compatibility with existing engine design
  - compatibility with anticipated EPA Phase III emission requirements
  - increased fire/burn risk
  - cost



# Public Affairs and CPSC Documents

- Initiative with retailers to increase public awareness of the CO hazard associated with generators:
  - Posting safety information
  - Selling other products in close proximity to the generators (i.e. CO alarms, heavy-duty extension cords, and chains and locks to prevent theft)
  - In the near future, additional efforts with the retailers will be initiated to include developing plans for employee training on safe generator use and safety training for customers.
- Press releases and posters
- “CPSC Safety Alert: Portable Generator Hazards” on-line document
- “Invisible Killer” publication, also available on-line
- “Responding to Residential Carbon Monoxide Incidents: Guidelines for Fire and Other Emergency Response Personnel” publication, also available on-line



# For more information...

- Go to:

<http://www.cpsc.gov/volstd/engine/engine.html>

- Contact:

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