

U.S. Consumer Product Safety Commission



Staff Review of Portable Generator Safety

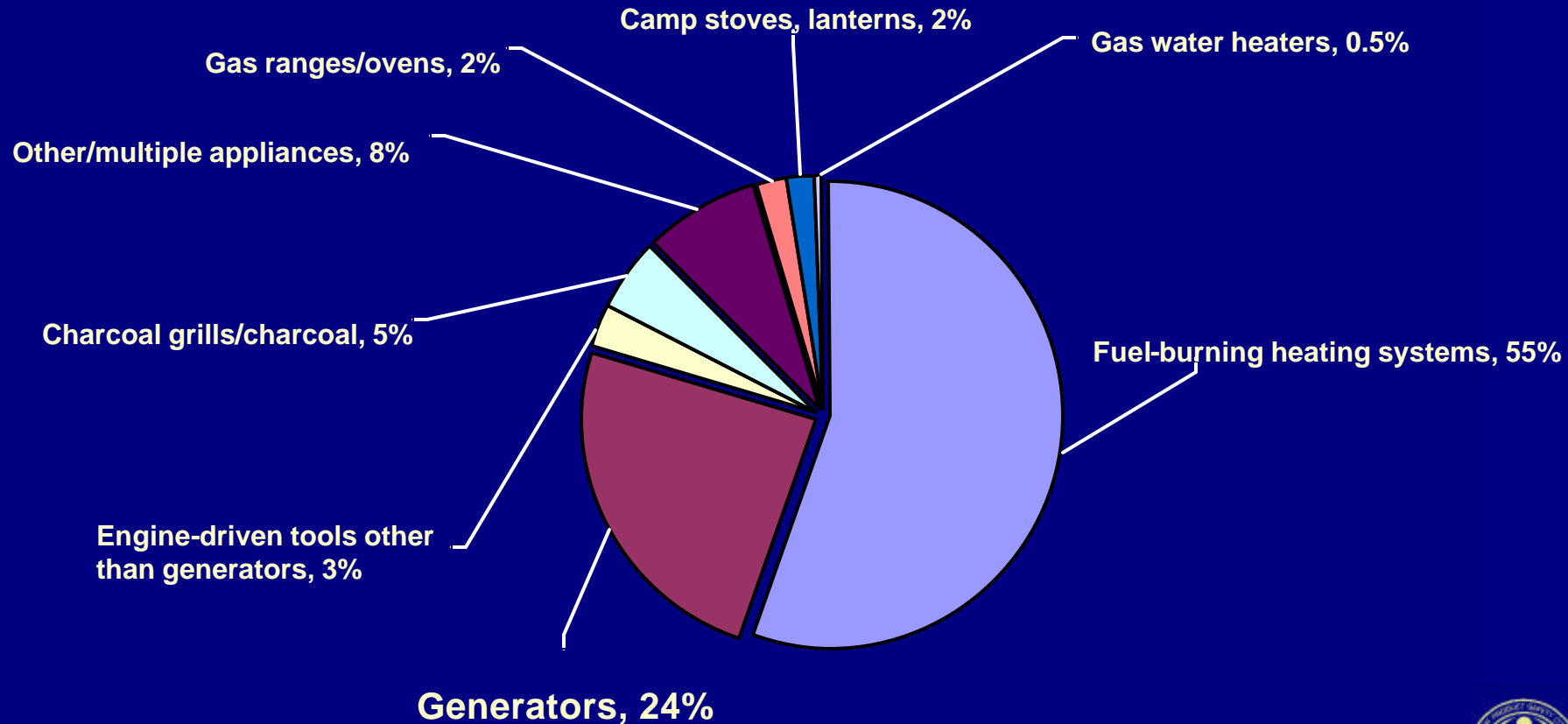
Briefing to the Commission
October 26, 2006

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.



CPSC Strategic Goal to Reduce CO Poisoning Deaths

Estimated CO Deaths by Category of Consumer Products, 2002



Product Information

- Fuel: Gasoline, diesel, propane, natural gas
- Electricity out: Cord-connected to appliances via receptacles (120v, 240v) or to house wiring via transfer switch
- Primarily contractor market before 1999
- Consumer market growing rapidly since pre-Y2K
- Sold through home centers, hardware stores, discount retailers

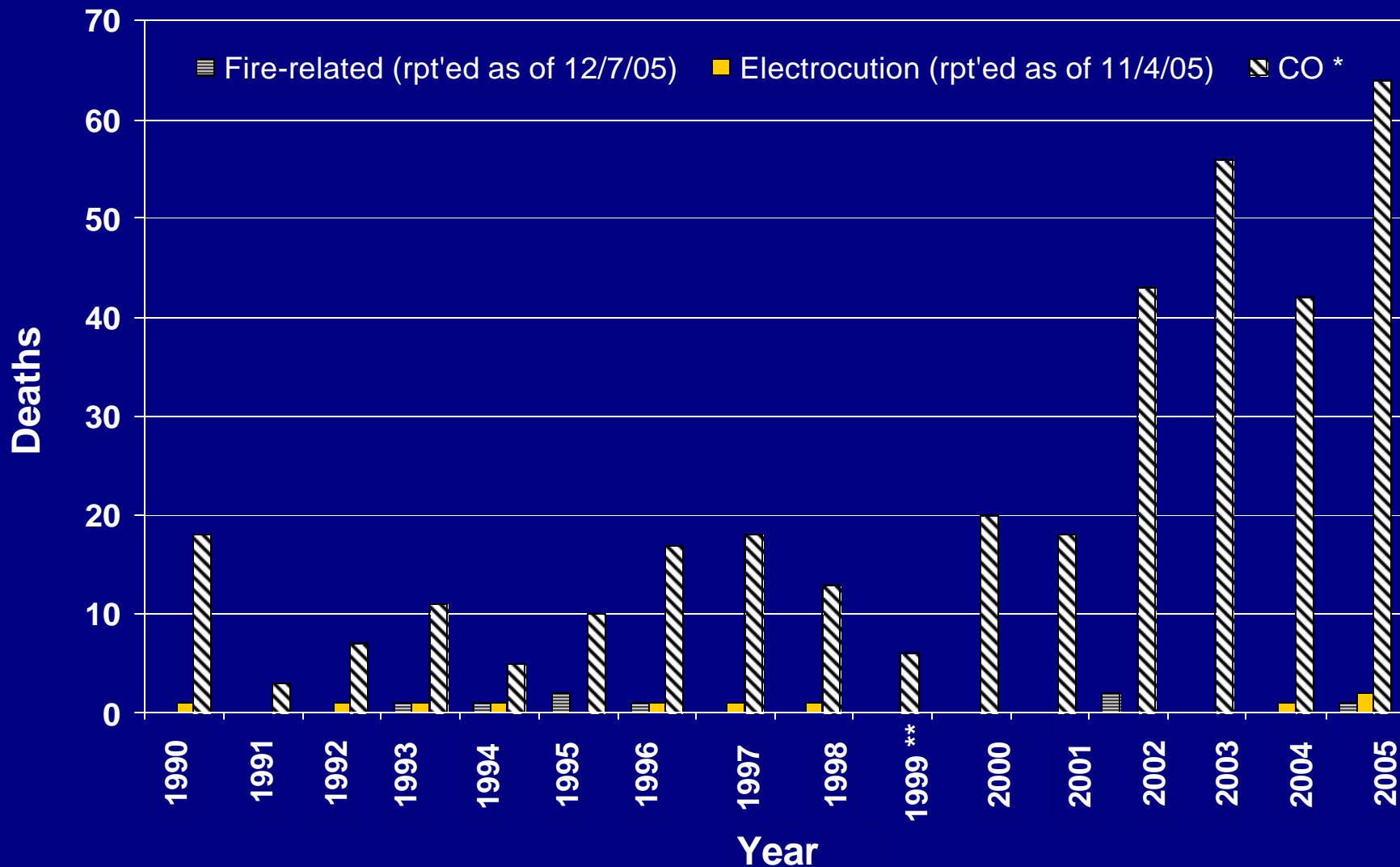


Hazards from Portable Generators

- CO poisoning
- Shock and electrocution
- Fire
- Thermal contact burns



Generator-Related Deaths Reported to CPSC



* For the years 1990 through 2001, these were the number reported to CPSC as of 6/27/2005. For the years 2002 through 2005, these were the number reported to CPSC as of 6/1/2006.

** The ICD-10 System was implemented in 1999.



Estimates of CO Injuries

- Reports of fatal generator CO incidents often include survivors with severe CO injuries
- CPSC staff does not make national estimates of CO injuries
 - NEISS records lack enough detail to confirm injury and associated consumer product
 - Mild CO poisoning cases may be confused with common illnesses
- Survivors of serious CO exposures, from any source of CO, could be affected with severe disabilities
 - Permanently with blindness, Parkinsonism, paralysis
 - Temporarily with emotional instability, memory loss, dementia, psychosis, incontinence, peripheral neuropathy, blindness, Parkinsonism, paralysis



Summary of Investigated Fatal CO Incidents*

Out of 137 fatal incidents involving 189 deaths:

- 60 deaths: generator used during weather-induced power outage or problem with power distribution.
- 146 deaths: occurred at home; majority with generator in the basement/crawlspace, garage/enclosed carport, or living space of the home.
- 24 deaths: appears consumer attempted to vent the indoor space where generator was operated.
- 5 deaths: generator was outside the home but near an open window, door, or vent.

* From incidents that occurred through 2004 that were reported to CPSC by 6/27/05, a total of 274 deaths. National totals may not be derived from this data as it is not a statistical sample.



Summary of Investigated Fatal CO Incidents*

- 5.0 kW – 5.9 kW generator most commonly involved, when identified in IDI
- Two most common reasons for using the generator indoors:
 - Fear of generator theft
 - Concern about noise to neighbors
- Almost all generators were referred to as gas or gasoline generators

* From incidents that occurred through 2004 that were reported to CPSC by 6/27/05, a total of 274 deaths. National totals may not be derived from this data as it is not a statistical sample.



Consumer Portable Generator Ownership and Sales

- 10.6 million units estimated in households in 2005, up from 9.2 million units in 2002*
- >1 million/year bought in 2003-2005**
- Approximately 40% bought in 2003-2005 were rated 5.0 kW to <6.5kW
- 60% of sales to consumers cost \$300 - \$800 per unit
- 98.7% of portable generators sold in 2003-2005 were gasoline-fueled

Sources: * Synovate, Inc.

** Multi-Client Research Group, Synovate, Inc.



Societal Cost Estimate of Generator CO deaths

- 51 CO deaths/year, 2002-2005 average
- Average annual societal cost is \$255M; ~\$25 annual societal cost per generator
- Based on 7-yr product life, estimated present value of expected societal cost/generator is \$157
- Expected benefits for reduction in the hazard resulting from intervention
 - 50% effectiveness: \$79/generator
 - 75% effectiveness: \$118/generator

Estimate does not include societal costs related to deaths from electrocution and fire or any injuries



Possible Strategies to Address CO Poisoning Hazard

- Reduce consumer exposure to CO through technical means
 - Engines with *substantially* reduced CO emissions
 - Automatic shutoff devices
- Enable and encourage proper generator placement
 - Weatherization requirements
 - For safe outdoor use in wet conditions
 - For engine operation in icing conditions
 - Theft deterrence
 - Noise reduction
 - Improved CO warning label and manufacturers' guidance



Possible Strategies to Address CO Poisoning Hazard (cont)

- Private sector consortium
- Information and education



Technical Approaches to Reduce Consumer Exposure to CO

Goal: Protect consumers against CO poisoning that can result in death or in serious and/or lasting adverse health effects if they inadvertently operate generator in improper location

NOT TO MAKE GENERATORS SAFE FOR INDOOR USE!



CO Hazard Characterization

- Testing to determine CO generation rate of 5.5 kW generator
- Modeling of most common incident scenario with generator operated in basement
 - Predicted all occupants dead before fuel tank exhausted
 - 40 minutes for person in basement
 - Less than 5 hours for person in 2nd floor bedroom
- 10 hp generator engine produces CO at rate 450-1000 times that of modern idling cars*

* Reference for idling automotive emissions: 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.



Engines with Reduced CO Emissions

- Most reliable way to limit consumer exposure is to limit production of hazardous CO levels at the source
- Automotive engines
 - Catalytic converters reduced CO emission by 96%
 - Still unsafe to run in garages, but unintentional CO deaths declined >80%
- Marine generator engines
 - 2 major manufacturers voluntarily reduced CO emissions >99% using catalytic converters and electronic fuel injection
 - Reduce CO poisonings on and around houseboats



Are Substantial CO Emission Reductions Possible for Generator Engines?

- Respondents to RFI assert 90-95% reduction in CO emissions is readily achievable
 - Catalytic converters alone or in conjunction with electronic fuel injection
- CPSC staff awarded contract to develop a low-CO generator prototype and demonstrate technical feasibility



Potential Impact of CO Emission Reductions

- Staff predicts that 90-95% reduction will result in improved survivability for most common incident scenario with generator improperly operated in basement
 - Can likely result in significant delay and reduced severity of CO exposure for all occupants, except those persons in the basement
 - Allows them more time to become aware of symptoms and escape
 - Depending on where they are in the house, they could survive without serious adverse effects even if they didn't leave the house
- Established interagency agreement with NIST to estimate minimum CO emissions reductions to improve survivability when generator improperly operated in garage
 - Identify engine modifications necessary to achieve this level of reduction



Are Substantial CO Emission Reductions Practical for Generator Engines?

- Catalysts are in use on motorcycles in U.S., motor scooters in Asia
- Catalysts will be introduced onto engines used on generators to meet proposed CARB and yet-to-be proposed EPA regulations
- Address technical and human factors issues
 - Potential for catalyst heat increasing fire and burn hazards
 - False sense of security leading to improper placement



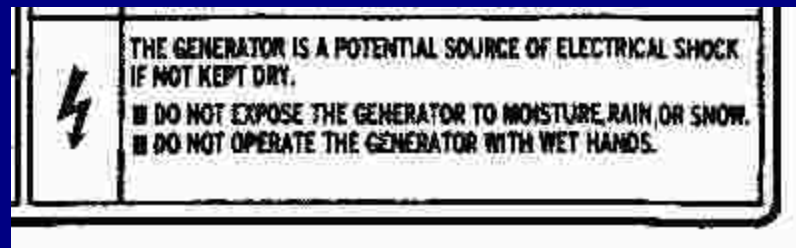
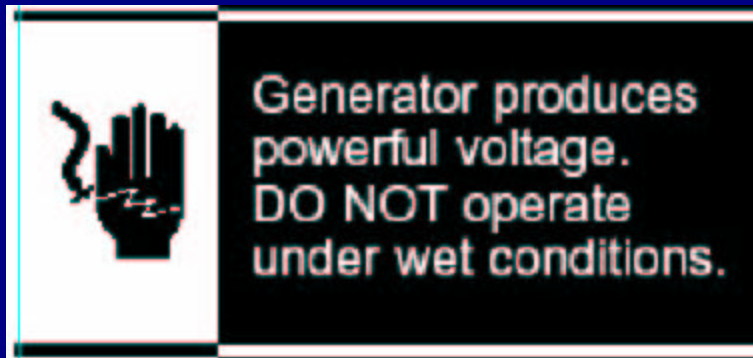
Interlocking or Auto Shutoff Devices

- Sensors shutoff generator if CO buildup is detected
- CPSC staff demonstrated proof-of-concept for two approaches
 - Detect CO in vicinity of operating generator
 - CO sensor mounted on generator
 - Detect CO where occupants are located
 - CO sensor in home with wireless connection to generator
- Address technical and human factors issues
 - Sensor reliability and durability
 - Locating in-home sensors in proper locations
 - False sense of security



Enable and Encourage Proper Generator Placement: Weatherization Requirements

- Generators are not constructed for safe use in wet conditions



- Wet conditions often exist when there is a power outage
- Current CO warning labels do not unequivocally advise against indoor use



Examples of CO Warnings Found on Generators

Provide proper ventilation! Do not operate in a confined area due to carbon monoxide poisoning!

STARTING INSTRUCTIONS: Check oil and fuel level. Disconnect entire electrical load from unit. On units not 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.

STOPPING INSTRUCTIONS: 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.

WARNING: 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 residence 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.

INSTRUCTIONS METTRE EN MARCHÉ: 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 (amorce) si nécessaire. Régler le levier d'engagement à la position "ON" ou "RUN (marche)". Tirer la corde de lancement d'un mouvement rapide. Ajuster le volet de départ tandis que l'appareil se réchauffe.

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

MISES EN GARDE Lire et bien comprendre le 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 à cause du danger d'empoisonnement au monoxyde de carbone. Pour éviter les brûlures, ne pas toucher le système d'échappement ou le moteur avant qu'il ne soit refroidi! Ne pas utiliser sous la pluie ou la neige, un choc électrique peut-être mortel peut se produire! Brancher l'appareil à une masse appropriée. Ne pas faire le plein dans un endroit confiné ou lorsque le moteur est en marche. Laisser le moteur refroidir 2 minutes avant de faire le plein. L'essence est extrêmement 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 à la propriété, seul un électricien formé doit brancher le générateur au système électrique de la résidence. La loi de Californie exige l'isolation du système électrique résidentiel avant de raccorder un générateur au système électrique résidentiel.

INSTRUCCIONES PARA PONER EN MARCHA: Revise los niveles del aceite y del combustible. Desconecte completamente la carga de electricidad de la unidad. Abra la válvula de combustible si acceso hay. Ajuste el choke(otraj) 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 eléctrico). Ajuste el choke hasta que el motor caliente.

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

ADVERTENCIAS: 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 estén enfriados! No haga funcionar bajo la lluvia ni la nieve. Una descarga eléctrica puede ser el resultado y puede ser fatal. Conecte la unidad 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 gasolina es sumamente inflamable y puede 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 la electrocución o daños materiales, unicamente un electricista calificado debe conectar el grupo electrógeno al sistema de electricidad de residencia las leyes de California exigen el aislamiento del sistema de electricidad de residencia antes de conectar un grupo electrógeno al sistema de electricidad de residencia.







HOT SURFACE





CHAUDE

SUPERFICIE CALIENTE



Examples of CO Warnings Found on Generators, cont'd

⚠ 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.
194799	

⚠ WARNING		⚠ WARNING	
	<p>GASOLINE IS HIGHLY FLAMMABLE AND EXPLOSIVE. YOU CAN BE BURNED OR SERIOUSLY INJURED WHEN HANDLING FUEL.</p> <ul style="list-style-type: none"> ■ STOP THE ENGINE AND KEEP HEAT, SPARKS, AND FLAME AWAY. ■ HANDLE FUEL ONLY OUTDOORS. ■ DO NOT FILL THE FUEL TANK ABOVE THE UPPER LIMIT LINE. ■ WIPE UP SPILLS IMMEDIATELY. ■ AFTER OPERATION, TURN THE ENGINE SWITCH AND FUEL TANK CAP LEVER TO THE "OFF" POSITION PREVENT FUEL LEAKAGE. 		<p>IMPROPER CONNECTIONS TO A BUILDING CAN ALLOW ELECTRICAL CURRENT TO BACKFEED INTO UTILITY LINES, CREATING AN ELECTROCUTION HAZARD.</p> <ul style="list-style-type: none"> ■ CONNECTIONS TO A BUILDING MUST ISOLATE GENERATOR POWER FROM UTILITY POWER AND COMPLY WITH ALL APPLICABLE LAWS AND ELECTRICAL CODES.
	<p>CARBON MONOXIDE GAS IS TOXIC. BREATHING IT CAN CAUSE UNCONSCIOUSNESS AND EVEN KILL YOU.</p> <ul style="list-style-type: none"> ■ AVOID ANY ENCLOSED AREAS OR ACTIVITIES THAT EXPOSE YOU TO CARBON MONOXIDE. 		<p>THE GENERATOR IS A POTENTIAL SOURCE OF ELECTRICAL SHOCK IF NOT KEPT DRY.</p> <ul style="list-style-type: none"> ■ DO NOT EXPOSE THE GENERATOR TO MOISTURE, RAIN, OR SNOW. ■ DO NOT OPERATE THE GENERATOR WITH WET HANDS.

Weatherization Features

- Raintight or rainproof enclosure
- In-use weatherproof receptacle covers
- Ground fault protection for all receptacles

- These features may not be practical for some generator models or eliminate electrocution risk under severe conditions (e.g., flood)



Weatherization Requirements

Icing conditions that can bring down power lines can also cause engine to stall

COLD WEATHER OPERATION

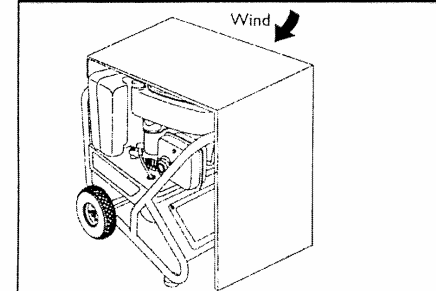
Under certain weather conditions (temperatures below 40°F [4°C] combined with high humidity), your generator may experience icing of the carburetor and/or the crankcase breather system. To reduce this problem, you need to perform the following:

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.
<ul style="list-style-type: none">• 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.
<ul style="list-style-type: none">• 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).	

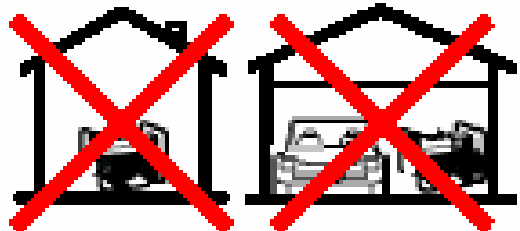
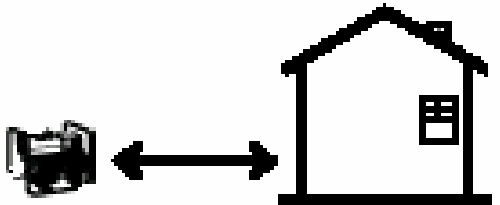
12. DO NOT enclose generator any more than shown in Figure 10.
13. Remove shelter when temperatures are above 40°F [4°C].
14. Turn engine OFF and let cool two (2) minutes before refueling.

Encourage Proper Generator Placement

- Deter generator theft
 - Mechanical devices to anchor, lock generator
- Reduce engine noise



Improve On-Product CO Warning Label

⚠ DANGER	
Using a generator indoors WILL KILL YOU IN MINUTES. Exhaust contains carbon monoxide, a poison gas you cannot see or smell.	
 <p>NEVER use in the home or in partly enclosed areas such as garages.</p>	 <p>ONLY use outdoors and far from open windows, doors, and vents.</p>

Improve Manufacturers' Guidance

Current guidance may mislead consumers:



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).

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



Private Sector Consortium

- A formal collaboration among manufacturers to develop effective technologies to address the hazard
 - Needs Dept. of Justice approval
 - Pooling resources to achieve common goal
 - Can accelerate product development: *or*
 - Can also impede progress if no consensus on approach
- Consortium developed Flammable Vapor Ignition Resistant water heaters



Information and Education

- CPSC's Office of Public Affairs
 - Press releases, VNRs, posters, publications
 - Targeted distribution to regional outlets in anticipation of major storms or in conjunction with widespread outages
- Expansion of I&E efforts to include all stakeholders
 - Establish consistency in messages concerning the hazard and proper operation of generator
 - Initiative with retailers to increase public awareness of the CO hazard associated with generators
 - National education program delivered at community level



Cost Estimates of Strategies

- Engines with substantially reduced CO emissions: \$40-\$200 per RFI respondents
 - In anticipation of CARB/EPA compliant engines with catalysts, staff expects lower cost
- Remote CO detection auto shutoff device: \$100
- Theft deterrent features/accessories: \$20
- National education program: > \$3M per year



Standards & Regulations

- Draft voluntary standard UL 2201
- UL Outline of Investigation, Subject 2201
- ISO 8528-8:1995(E)
- CSA C22.2 No. 100-04
- OSHA regulations



Participation in Development of UL 2201

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



UL Outline of Investigation, Subject 2201

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

- Establishes certification requirements for generators to receive the UL mark
- Includes requirements for
 - features that will permit safe use in wet conditions
 - warnings about CO poisoning on product and packaging and in instruction manual
- UL sought and received staff's comments and recommendations
- Not currently a consensus document



ISO, CSA, OSHA Requirements

- ISO 8528-8:1995(E) *Reciprocating IC Engine Driven AC Generating Sets – Part 8: Requirements and Tests for Low-Power Generating Sets*
 - CO hazard addressed through labels and markings
 - Requires start-up and operation at temps 5°F to 104°F
- CSA C22.2 No. 100-04 *Motors and Generators*
 - No requirements to address CO hazard
- OSHA Regulations
 - Define proper installation and use of portable generators at a temporary construction site or permanent workplace in which portable generator is supplying power
 - Address grounding and ground-fault protection

These documents do not adequately address the CO poisoning hazard for portable generators.



Conclusions and Recommendations

Effective intervention is urgently needed to address increasing CO deaths.

- Deaths occur predictably with severe weather.
- They also occur throughout the year, independent of weather.
- Consumer ownership is increasing.
- There is inadequate progress in developing effective voluntary standards that address the CO poisoning hazard.
- Most reliable way to address consumer exposure to CO is to reduce it at its source. This appears to be achievable. Cost and practicality will be assessed.
- Enabling and encouraging consumers to operate their generators in safe locations will help.

Staff recommends publishing an ANPR to initiate rulemaking in addition to pursuing non-regulatory options.

