Carbon Monoxide

A potential hazard in Naval Shore Facilities

This paper is to alert and remind designers, construction inspectors, ROICC's, housing administrators, maintenance personnel, and occupants of the hazards, causes, and precautions necessary to avoid further injury and loss of life due to carbon monoxide poisoning.

Enclosure 1) is COMNAVSAFECEN msg R301830Z OCT 98.
Enclosure 2) is COMNAVFACENGCOM msg R191412Z NOV 98.
Enclosure 3) is CNO//N05100// msg R101307Z MAY 99.
Enclosure 4) is Naval Facilities Engineering Command Guide Specification, NFGS-13856, CARBON MONOXIDE DETECTORS, dated 24 May 1999.
Enclosure 5) is a reprint of an article in Plumbing Engineering magazine, edition July 1999.

Enclosure 1 describes the symptoms and effects of carbon monoxide poisoning, the known death and injury toll within the Navy in the last 10 years, and some steps the home owner/occupant may take to improve safety.

Enclosure 2 directed the installation of carbon monoxide monitors in Navy Family Housing.

Enclosure 3 directed a review of maintenance operations in regard to Navy Family Housing to insure proper inspection, and repair procedures are utilized, and inspection of combustion air inlet ducts for fire dampers. Reporting is required.

Enclosure 4 is the latest revision of Naval Facilities Engineering Command Guide Specification (NFGS) from NAVFAC 15G/SLC 46, at 4111 San Pedro Street, Port Hueneme, CA 93043-4410, Phone (805) 985-5661 or 6087 or DSN 551. Use battery units in retrofit in CONUS, unless walls are opened for new electrical work, then use hard-wired or plug-in detectors. OCONUS areas, use hard-wired or plug-in units for new construction if 120 VAC is available, otherwise use battery units..

Enclosure 5 discusses Combustion Air and Venting from the Building Inspector's point of view.

These five enclosures are provided to reduce the designer's effort to obtain them from command files, since designers are not usually the message addressees.

DETECTION.

Carbon Monoxide Detector Installation. Install carbon monoxide detectors in accordance with the manufacturer's instructions. Install at least one CO detector per floor for multi-floor units. Locate a carbon monoxide detector immediately outside of the bedrooms, to wake all sleepers. Install the CO detectors several feet away from any wall to wall, wall to ceiling, or wall to floor corner; out of the supply-air discharge path; not in the return-air path; nor in the path of any fan suction or discharge. Carbon monoxide is only slightly less dense than air, but since it is usually heated, the most suitable location is near the ceiling. This also serves to keep the detector away from children's exploring fingers. In facilities with cathedral ceilings, install the CO detector on the wall, about 5 to 8 feet above the floor. If you must put one in the kitchen-breakfast nook-family room area, keep it at least 15 feet away from the range and oven. Do not install detectors in the same room as the combustion equipment (garages, laundry rooms, closets). Keep the detector away from fireplaces and wood stoves. Keep the detector away from areas of high humidity, such as showers, baths, washers, dryers, and dishwashers; the humidity may cause false alarms.

SOURCES OF CARBON MONOXIDE.

There is the potential for creation of carbon monoxide, and for carbon monoxide poisoning, when any combustion source is not properly vented, installed, operated, and maintained.

Typical CO Sources. The following lists some typical sources of CO:

Hot Air Furnace – oil or gas fired
Hot Water Boiler – oil or gas fired.
Hot Water Heater – oil or gas fired.
Clothes Dryer – gas fired.
Kitchen Ranges and Ovens – gas fired.
Fireplaces and Wood Stoves – including gas logs, coal, cord wood, and wood-pellet fueled.
Kerosene Space Heaters – radiant or convection type, home or shop usage.
Engines - gasoline and diesel, including yard equipment, electric generators, sports equipment.
Outside Air Intakes - located near operating gasoline or diesel engines, stationary or mobile.
Smoking – cigarette, cigar, or pipe.

Typical Flue Gases. Flue gases may contain as much as 400 PPM of carbon monoxide for well adjusted gas burners. Improperly operating burners may produce many times that concentration. Thus, all flue gases should be considered hazardous. The emissions from gas range and oven pilot lights and burners are ordinarily safe, due to the clean burning characteristics of the fuel and the relatively small amount of fuel consumed. Attempting to heat the residence with the gas range and oven burners is dangerous because this attempt greatly increases the amount of fuel consumed within the unit, thereby greatly increasing the emissions.

Hot Air Furnace Heat Exchanger Leakage. A typical residential hot air heating system burns a liquid (heating oil or kerosene) or gas (natural gas or LPG) fuel in a forced air or natural draft burner. The hot gases pass through a heat exchanger where the heat is transferred to the air returning through the air filter from the residence, prior to being sent back heated to warm the house. The metal in the heat exchanger is thin, to maximize heat transfer and energy efficiency. Each time the furnace is energized in the heating mode, the heat exchanger expands and contracts. The normal design life for this component is 15 years, and 20 years for premium quality corrosion resistant construction. Corrosion may thin and pit the heat exchanger metal; this corrosion may be accelerated by laundry bleach chlorine mists from nearby clothes washing machines; or by leaking chlorinated refrigerant from air conditioning equipment.

Dirty Furnace Air Filter and Blockages. Blockages in the supply and return air passages may reduce the room air flow to the heat exchanger, increasing the temperature of the heat exchanger by failing to take away the heat as it was designed. Blockages in the flue gas passages and in the combustion air flow to the burner may reduce the flow of flue gases and alter the temperature distribution in the heat exchanger, increasing the temperature of the first part of the heat exchanger. These temperature increases will increase the amount of expansion and contraction of the heat exchanger. This additional expansion and contraction increases the potential for crack formation. These cracks and any corrosion pits may allow the carbon monoxide from the flue gases to be drawn into the air supplied to the residence.

Blockage of the combustion airflow to the burner may increase the production of carbon monoxide. Blockages in the flue gas passages may also increase the flue gas pressure in the heat exchanger, which can cause increased leakage through any existing heat exchanger cracks or pits.

Hot Water Boiler. Blockage of flue gas passages, leakage of flue gas piping, and blockage of combustion air passages in hot water boilers create carbon monoxide problems similar to those of hot air furnaces, except there is no air leakage through the heat exchanger. Any heat exchanger leakage reveals itself as a hot water puddle or flood. These water leaks should be investigated promptly to avoid damage to persons or property.

Gas-fired Natural-draft Water Heaters and Hot Air Furnaces. These appliances are equipped with a draft hood (draft diverter), the upside-down cone just above the top of the water heater or furnace. Blockage of the flue passages within the water heater or furnace, or the flue passages to outdoors may cause carbon monoxide to back up in the flue and spill into the closet or room housing the water heater or furnace. The return air for the furnace is often taken from this space. Units installed in CONUS since 1987 should have been equipped with a flame roll out safety switch, which shuts off the appliance if spillage occurs for too long a period. Ensure this switch is installed and in good working order.

Attached Laundry Room or Garage Installation. Locating the gas or oil fired hot air furnace, gas or oil fired water heater, or gas dryer in the attached laundry room or garage, may allow carbon monoxide from these appliances to be drawn into the residence. The CO may be drawn through the door, or through cracks in the partition wall, crawl space, attic space, or furnace return air ducts. Even the installation of the clothes washer in the attached garage or laundry room may increase the chance of carbon monoxide being drawn into the residence from any nearby fuel-fired appliances. This is due to the increased traffic through the door, resulting in increased air and fume movement into the residence while doing the laundry.

Do not start, warm up, tune up, or operate any automobile, motor cycle, snow mobile, boat, personal water craft, lawn mower, generator, or other engine driven machine inside, or near the open door to, the attached garage or laundry room. Carbon monoxide concentrations may build up quickly, especially if there are other fuel burning appliances operating in the laundry room or garage. If operating an engine outdoors, make sure the exhaust is not entering the residence through open doors, windows, or outside air intakes, including window air conditioners.

Fireplace or Wood Stove. Burning wood, wood pellets, coal, or gas logs with a closed or broken flue damper, blocked or cracked chimney or flue, or a bird or other animal nest blockage all may cause carbon monoxide intrusion into the room. In addition, the great quantity of draft up the chimney, early and throughout most of the burning process, may cause other fuel burning appliances to back-draft, particularly those equipped with draft hoods. Late in the fireplace or wood stove burnout process, the emissions of carbon monoxide tend to increase; at about the same time, the natural draft decreases. This condition may allow carbon monoxide from the fireplace or wood stove to now back-draft into the room, if other fuel burning appliances, or exhaust fans are operating, or even if down-wind windows are opened. Leave the flue damper open long after the fire is out and the ashes are cold. Closing the flue damper too early may divert the carbon monoxide into the room.

Gas-fired Clothes Dryers. These dryers have a flue/exhaust duct that is vented outdoors. Blockage may force carbon monoxide into the laundry room. Lint will tend to collect in the dryer flue/air exhaust duct. This will reduce the airflow, lengthen the time to dry the clothes, and increase the possibility of damaging the clothes and dryer. Clean the dryer air filter before every load, and clean the dryer flue/exhaust duct every month. This is also good practice for electric-heat clothes dryers, in order to reduce the chance of a lint fire.

Additional Factors. The operation of exhaust fans in kitchens, laundry rooms, and bathrooms; window fans; and clothes dryer fans may result in increasing the potential for carbon monoxide in the residence. All may remove more air from the residence than can be readily replaced from outside – especially from new, tightly constructed energy-efficient residences. If these fans reduce the air pressure inside the residence by as little as 0.02 to 0.05 inches of water below outside air pressure, the flow of flue gasses can be reversed in draft-hood equipped appliances, such as water heaters, gas fired clothes dryers, and natural draft furnaces. This may allow flue gasses to be admitted into the occupied space.

RECOMMENDED ACTIONS.

Suggested Actions for Engineers and Designers, on new construction and major renovations. Select equipment that does not generate carbon monoxide, if economically possible. Locate fuel burning equipment outdoors, if possible; such as packaged slab mounted HVAC units. Select direct venting units that use outside air for combustion and exhaust back to the outside air.

Design all connections for combustion air and exhaust in accordance with the International Mechanical Code (IMC) requirements and the manufacturer's installation instructions. If any volume, smoke, or fire damper is located in the combustion air path, the damper shall be electrically interlocked to prevent burner operation of any device drawing combustion air through that duct or room when any such damper is closed, per IMC 710.2.

Carefully size flues and chimneys for new construction. Ensure proper sizing of existing flues and chimneys if retrofitting new, more efficient equipment to existing construction. Over-sized flues and chimneys reduce the draft and over-cool the flue gasses; under-sized flues and chimneys prevent the safe venting of the flue gasses, and both may lead to carbon monoxide accumulation. Provide adequate height and horizontal clearances for vents and chimneys from windows, doors, and air intakes.

Provide easy access to supply and return air ducts, and outside air and exhaust flues for inspection and repair. Locate equipment with sufficient clearance for inspection and repair.

Specify the furnace return duct test and the basic depressurization test. Provide ample make up air supply from outdoors. The make up air quantity must equal the sum of all exhaust fans that might run during the heating season (such as the kitchen exhaust, bathroom exhaust, and clothes dryer exhaust) plus the combustion air, excess air, and dilution air requirements of all fuel burning appliances within the enclosed space. See ASHRAE HVAC Systems and Equipment, Chapter 30, Table 2 and the section on draft hoods and draft regulators for estimates of typical chimney design conditions.

ASHRAE STD. 62-1989, Ventilation for Acceptable Indoor Air Quality, Table C-1 sets the, acceptable indoor air quality limits for CO equal to the National Primary Ambient-Air Quality Standards for Outdoor Air as set by the U. S. Environmental Protection Agency. ASHRAE STD. 62, Table 1., indicates the acceptable value for CO indoors is less than 9 parts per million (PPM) average for eight hours, and less than 35 PPM for one hour, both not to be exceeded more than once per year.

Provide carbon monoxide detectors, indicate proper locations, and provide power.

Suggested Actions for Design-Build Procurement. Award points for corrosion resistant heat exchangers, metal air ducts, and direct connections of combustion air.

Suggested Actions for Construction Inspection. Verify installations are in accordance with the Construction Documents, IMC, and Manufacturer’s instructions. Observe and verify air balance and air flows in supply, return, makeup, and combustion air ducts or paths.

Insure tight construction of return air ducts and flues. Smoke-test the ducts and draft diverters to reveal leaks and back-drafts. Observe satisfactory completion of the furnace return duct test and the basic depressurization test. Ensure all fossil-fueled appliances are properly vented.

Test fuel-fired furnace, boiler, and water heater flue gases, and measure the efficiency of the furnace or boiler prior to acceptance. Record CO_2, CO, and efficiency data at acceptance on sticker attached to furnace or boiler, for future maintenance comparison purposes.

Verify CO detector operates, alarms, resets, and tests correctly.

Verify kitchen range and oven burners burn cleanly, sample the flue gases if necessary.

Suggested Actions for Property Management. Require written records be furnished by the inspector and maintain these records.

Provide the occupants with easy access to a supply of furnace filters, and batteries for CO detectors.

Suggested Actions for Occupants. Replace furnace air filters when dirty, or per instructions. Maintain area around fuel fired appliances clean and open. Test the CO detector monthly by pressing the test button and hearing the alarm sound. Replace batteries in CO detector as necessary.

Never heat the residence with the gas oven or range. Using a gas oven or range as a space heater greatly increases the emission of carbon monoxide within the occupied space. Do not heat or cook in the residence with charcoal, even in the fireplace. Open a window slightly when using an unvented gas oven. Do not operate engines inside the residence, attached garage, or near open windows or doors.

REFERENCES.

Designer's References. All designers should have available the following references in the **American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook Series:**

1995 HVAC Applications, Chapter 3, COMMERCIAL AND PUBLIC BUILDINGS, Transportation Centers, Special Considerations; Enclosed Garages, and Carbon Monoxide Criteria.

1995 HVAC Applications, Chapter 6, EDUCATIONAL FACILITIES, Design Considerations, Middle and Secondary Schools; Auto Repair Shops.

1995 HVAC Applications, Chapter 12, ENCLOSED VEHICULAR FACILITIES, Parking Garages; Contaminant Level Criteria.

1995 HVAC Applications, Chapter 24, VENTILATION OF THE INDUSTRIAL ENVIRONMENT; Table 4, Negative Pressures That May Cause Unsatisfactory Conditions Within Buildings (ACGIH 1992).

1995 HVAC Applications, Chapter 41, CONTROL OF GASEOUS INDOOR AIR CONTAMINANTS; Tables 2, 5, 8, and 9, along with Harmful Effects of Gaseous Contaminants.

1996 HVAC SYSTEMS AND EQUIPMENT, Chapter 26, Automatic Fuel-Burning Equipment, Engineering Considerations; Combustion Process and Adjustments.

1996 HVAC SYSTEMS AND EQUIPMENT, Chapter 28, Furnaces; The entire chapter is must reading.

1996 HVAC SYSTEMS AND EQUIPMENT, Chapter 29, Residential In-Space Heating Equipment; Gas In-Space Heaters, Oil and Kerosene In-Space Heaters, and Solid-Fuel In-Space Heaters.

1996 HVAC SYSTEMS AND EQUIPMENT, Chapter 30, Chimney, Gas Vent, and Fireplace Systems; Chimney Functions; Table 2; Vent and Chimney Accessories, Draft Hoods.

General References. Information readily available for download from the Internet includes the following:

ASHRAE: Indoor Air Quality Position Paper, 11 August 1987, at http://www.ashrae.org/About/iaq_papr.htm, Indoor Combustion.

Consumer Product Safety Commission Documents: #4464, THE "SENSELESS" KILLER, CAN YOU TELL WHAT IT IS?; #4466, CARBON MONOXIDE FACT SHEET; #5008, CPSC Warns of Carbon Monoxide Poisoning with Camping Equipment; #5010, Carbon Monoxide Detectors Can Save Lives; #5012, Burning Charcoal in Homes, Vehicles, and Tents Causes 25 Deaths from Carbon Monoxide Each Year; and #5052, CPSC and NKHA Stress Kerosene Heater Safety, at http://www.cpsc.gov.

Environmental Protection Agency Publications: Protect Your Family and Yourself from Carbon Monoxide Poisoning; Preventing Carbon Monoxide Poisoning from Small Gasoline-Powered Engines and Tools; and Building Air Quality, *A Guide for Building Owners and Facility Managers*, at http://www.epa.gov/iedweb00/pubs/. The BAQ publication has a good discussion on carbon monoxide sources, effects, tests, and solutions for larger buildings and facilities.

Wayne State University: Carbon Monoxide Headquarters; Allowable (Legal) Limits for CO; History of Carbon Monoxide; and CO Danger in the Garage; at http://www.phypc.med.wayne.edu, Carbon Monoxide Headquarters button. This site has links to many more sites.

Charleston Air Force Base, S. C. describes two recent incidents at that location including a first person account by a LT. COL. Air Force Nurse, available at http://www.af.mil/news/Dec1998/n19981210_981914.html and at http://www.charleston.af.mil/chas/437aw/staff/pa/dispatch/jan29/head2.htm.

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SUBJ/HAZARD ALERT (CARBON MONOXIDE-INVISIBLE AND DEADLY)//

RMKS/ 1. AS LEAVES CHANGE COLOR, DAYS GROW SHORTER AND THE NIGHTS GET COLDER, WE SWITCH OUR THERMOSTATS FROM AC TO HEAT. FOR THOSE OF US WHO DON'T HEAT WITH ELECTRICITY, THIS SWITCH CAN BE DEADLY. WHY? FURNACES THAT USE FOSSIL FUEL--NATURAL GAS, PROPANE, BUTANE, COAL, KEROSENE, WOOD OR OIL--DEPEND UPON EFFICIENT MIXTURES OF AIR AND FUEL TO PROVIDE COMPLETE COMBUSTION. FURNACES THAT DON'T BURN CLEANLY, OR IN WHICH THE EXHAUST GASES ARE BLOCKED, OR THAT DON'T GET ENOUGH OXYGEN, CAN KILL UNSUSPECTING RESIDENTS. THE CULPRIT IS CARBON MONOXIDE, A COLORLESS, INVISIBLE, ODORLESS GAS PRODUCED WHEN FUELS DON'T BURN COMPLETELY.

2. CARBON MONOXIDE ACTUALLY STARVES THE BRAIN AND BODY OF OXYGEN BECAUSE IT REPLACES OXYGEN IN THE BLOODSTREAM, EVENTUALLY SUFFOCATING THE VICTIM. SYMPTOMS RANGE FROM MILD HEADACHE WITH LOW LEVEL EXPOSURES TO NAUSEA, DIZZINESS, LOSS OF CONSCIOUSNESS AND DEATH AS EXPOSURE TIME AND CONCENTRATION INCREASES. JUDGEMENT AND THOUGHT PROCESSES BECOME IMPAIRED AND VICTIMS ARE OFTEN UNABLE TO REACT IN TIME TO SAVE THEMSELVES. LITERALLY, YOU CAN DIE WITHIN MINUTES OF EXPOSURE. CHILDREN, PEOPLE WITH HEART PROBLEMS OR RESPIRATORY ILLNESS, AND THE AGED ARE PARTICULARLY SENSITIVE TO ITS EFFECTS.

3. HEALTHY, STRONG ADULTS ARE VULNERABLE AS WELL. RECENTLY A NAVY MAN AND HIS FOUR CHILDREN WERE FOUND DEAD IN THEIR HOME, SUSPECTED VICTIMS OF CARBON MONOXIDE POISONING. IN ALL, SEVEN OFF-DUTY SAILORS AND THREE MARINES DIED AS A RESULT OF CO POISONING IN FYS 89-98. FIVE OF THE TEN DEATHS WERE CAUSED BY DEFECTIVE HEATERS; FOUR BECAUSE THEY RAN THEIR CARS IN ENCLOSED AREAS; AND ONE FROM CO EXPOSURE IN A MOBILE HOME FIRE. INJURIES HAVE ALSO BEEN REPORTED, WITH FIVE CATEGORIZED AS MAJOR. ESTIMATES FOR CO POISONINGS IN THE GENERAL POPULATION RANGE FROM ABOUT 560 DEATHS PER YEAR BY THE CONSUMER PRODUCTS SAFETY COMMISSION TO 700 PER YEAR ACCORDING TO THE NATIONAL SAFETY COUNCIL.

4. TAKE THE FOLLOWING STEPS TO ENSURE THE SAFETY OF YOUR HOME:

A. HAVE A QUALIFIED TECHNICIAN INSPECT YOUR HEATING SYSTEM AND HOT WATER HEATER BEFORE THE HEATING SEASON BEGINS. IF YOU BUY AN OLDER HOUSE OR RENT AN APARTMENT OR HOME, HAVE THE SYSTEM CHECKED.

B. BUY HEATING AND COOKING EQUIPMENT APPROVED BY AN INDEPENDENT TESTING LABORATORY.

C. IF YOU LIVE IN BASE HOUSING AND USE SUPPLEMENTAL HEATERS, MAKE SURE THEY ARE PERMITTED. READ THE MANUFACTURER'S WARNING ABOUT VENTILATION. HAVE THEM INSPECTED BY A QUALIFIED TECHNICIAN EVERY YEAR.

D. NEVER USE A HIBACHI OR BARBEQUE GRILL INSIDE A HOME OR GARAGE.

E. ENSURE THE FLUE IS UNOBSTRUCTED BEFORE LIGHTING YOUR FIREPLACE.

F. NEVER LEAVE YOUR CAR OR TRUCK RUNNING IN THE GARAGE. DO NOT ASSUME OPENING THE GARAGE DOOR IS SUFFICIENT PROTECTION. WHEN YOU START IT, DRIVE IT OUTSIDE IMMEDIATELY. WHEN YOU RETURN, TURN THE MOTOR OFF WHEN YOU STOP. IF YOU SUSPECT THERE IS AN EXHAUST LEAK, HAVE IT REPAIRED IMMEDIATELY.

G. INSTALL A CARBON MONOXIDE DETECTOR INSIDE YOUR HOME TO PROVIDE EARLY WARNING. THESE DEVICES ARE DESIGNED TO SOUND AN ALARM WHEN THE CONCENTRATION OF CO IN THE AIR CORRESPONDS TO A LEVEL OF POISONING STILL SO LOW THAT PEOPLE DO NOT BECOME SICK. FOLLOW MANUFACTURER'S RECOMMENDATIONS FOR CORRECT PLACEMENT. TEST THE DEVICE EVERY MONTH AND REPLACE THE DETECTOR OR BATTERY AS RECOMMENDED, GENERALLY EVERY TWO YEARS.

H. IF YOU EVER THINK YOU ARE EXPERIENCING CO POISONING, GET INTO FRESH AIR IMMEDIATELY. OPEN DOORS AND WINDOWS. CALL FOR HELP OR GO TO AN EMERGENCY ROOM. DON'T WAIT.

5. ACT NOW TO PROTECT YOURSELF AND YOUR LOVED ONES. HELP KEEP OUR NAVY AND MARINE CORPS FAMILY SAFE.//

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RHHMHAH/CINCPACFLT PEARL HARBOR HI//09BH//
RHDLCNE/CINCUSNAVEUR LONDON UK//N7//
RULSSEA/COMNAVSEASYSCOM WASHINGTON DC//01K/04XI//
RULSFAN/COMNAVAIRSYSCOM PATUXENT RIVER MD//8.0B//
RUCCNOM/COMNAVRESFOR NEW ORLEANS LA//463//
RUCTPOA/CNET PENSACOLA FL//N44//
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SUBJ/REDUCING CARBON MONOXIDE RISKS IN NAVY FAMILY HOUSING//
RMKS/1. UNTIL RECENTLY, THERE HAVE BEEN NO FEDERAL OR DOD REQUIREMENTS TO INSTALL CARBON MONOXIDE (CO) DETECTORS IN NAVY FAMILY HOUSING. NAVY HAS RE-EXAMINED ITS POLICY ON INSTALLATION OF DETECTORS. TO PROTECT NAVY FAMILIES, AND RECOGNIZING THE RECENT IMPROVEMENTS IN RELIABILITY AND COST OF COMMERCIAL CO DETECTORS, DETECTORS SHALL BE INSTALLED IN ALL NAVY FAMILY HOUSING UNITS WHICH ARE SERVED BY CARBON-BASED FUEL BURNING SYSTEMS.
2. EFDS ARE DIRECTED TO ASSIST LOCAL HOUSING AUTHORITIES TO PURCHASE AND INSTALL CO DETECTORS. THE FOLLOWING GUIDANCE IS PROVIDED:
A. DETECTORS SHOULD BE INSTALLED IN ALL NAVY OWNED OR LEASED HOUSING UNITS, CONUS AND OVERSEAS, WHICH UTILIZE CARBON-BASED FUEL (NG, LPG, CHARCOAL, COAL, WOOD, KEROSENE, HEATING OIL) BURNING SYSTEMS (RANGES, WATER HEATERS, SPACE HEATING, CLOTHES DRYERS, FIREPLACES).
B. AT LEAST ONE DETECTOR SHOULD BE PROVIDED ON EACH FLOOR OF MULTI-FLOOR HOUSES.
C. DETECTORS SHOULD MEET THE FOLLOWING SPECIFICATIONS: DIGITAL DISPLAY, PEAK LEVEL MEMORY, BATTERY BACK-UP, MULTIPLE INSTALLATION OPTIONS, AC POWERED (BATTERY OVERSEAS), MINIMUM FIVE YEAR WARRANTY, IAS 6-96/AGA BLUE STAR CERTIFICATION.
D. DETECTORS SHALL BE PURCHASED USING AVAILABLE BP-20 FUNDS.
E. COORDINATION WITH LOCAL FIRE PROTECTION/PREVENTION ORGANIZATION IS RECOMMENDED. SUCH ORGANIZATIONS WILL OFTEN ASSIST IN INSTALLATION, TRAINING IN USE, AND PERIODIC OPERATIONAL TESTING OF CO DETECTOR UNITS.
F. ENSURE THAT SUITABLE MAINTENANCE AND SUPPORT ARRANGEMENTS ARE PUT IN PLACE TO ENSURE THE CONTINUING SERVICABILITY OF CO DETECTORS ONCE INSTALLED, INCLUDING: (1) ESTABLISHING AN APPROPRIATE MAINTENANCE REGIMEN (2) INCORPORATING MAINTENANCE EXPENSES IN BUDGET PLANS, AND (3) VERIFYING DETECTOR OPERATION DURING OCCUPANCY CHECK-IN/CHECK-OUT PROCEDURES.

G. EFDS ARE REQUESTED TO DEVELOP PLANS TO PURCHASE AND INSTALL CO DETECTORS, AND TO PROVIDE NAVFAC HSG THE FOLLOWING INFORMATION FOR EACH ACTIVITY BY 1 DEC 98. (1) NUMBER OF HOUSING UNITS WITH CARBON-BASED FUEL BURNING SYSTEMS, (2) NUMBER OF HOUSING UNITS WITH DETECTORS ALREADY INSTALLED THAT MEET SPECIFICATIONS (C) ABOVE, (3) NUMBER OF HOUSING UNITS REQUIRING DETECTORS TO BE INSTALLED, (4) NUMBER OF DETECTORS REQUIRED, (5) ESTIMATED COST TO PROCURE AND INSTALL DETECTORS, (6) ESTIMATED DATE TO COMPLETE DETECTOR INSTALLATION, AND (7) ACTIVITY AND EFD POC NAME, PHONE NUMBER AND E-MAIL ADDRESS.

3. IN ADDITION TO INSTALLATION OF CO DETECTORS, EFDS ARE REQUESTED TO ASSIST HOUSING ACTIVITIES TAKE THE FOLLOWING ACTIONS TO MINIMIZE RISKS FROM CO POISONING:

(A) PERFORM INSPECTION OF EXISTING CARBON-BASED FUEL BURNING SYSTEMS TO ENSURE PROPER OPERATION AND TAKE ACTION TO CORRECT DEFICIENCIES FOUND, (B) ALERT HOUSING OCCUPANTS TO THE DANGERS OF CARBON MONOXIDE POISONING. IN PARTICULAR, EMPHASIZE THE IMPORTANCE OF MAINTAINING PROPER AIR FLOW TO HEATING UNITS AND AVOIDING THE BLOCKAGE OF RETURN AIR GRILLES OR MAKE-UP AIR INTAKES.

4. NAVFACENGCOM POC IS DICK HIBBERT, 202 685-9381 OR DAN WONDERLY, 202 685-9352.//

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RUHEMCQ/COMNAVREG PEARL HARBOR HI//00//
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RHFJJCN/NAS JACKSONVILLE FL//00//
RUWHDCC/NAS JRB FORT WORTH TX//00//
RUCCAJC/NAS JRB NEW ORLEANS LA//00//
RUEDFLA/NAS JRB WILLOW GROVE PA//00//
RUCOPLF/NAS KEFLAVIK IC//00//
RHFJKXF/NAS KEY WEST FL//00//
RUWHKIF/NAS KINGSVILLE TX//00//
RUWFLBR/NAS LEMOORE CA//00//
RUCTPRF/NAS MERIDIAN MS//00//
RUCTPOB/NAS PENSACOLA FL//00//
RUWFPDE/NAS PT MUGU CA//00//
RUFEPSS/NAS SIGONELLA IT//00//
RHWIDIP/NAS WHIDBEY ISLAND WA//00//
PAGE 03 RUENAAA0534 UNCLAS
RUCTPTB/NAS WHITING FIELD MILTON FL//00//
RUEHRO/NATODEFCOL ROME IT//00//
RUDJAKA/NAVADMINU SCOTIA NY//00//
RULSEMB/NAVAIRENGSTA LAKEHURST NJ//00//
RULSABU/NAVAIRWARCENACDIV PATUXENT RIVER MD//00//
RUEGUAA/NAVCOMTELSTA CUTLER ME//00//
RUEHHK/NAVCONTDEP HONG KONG HK//00//
RUCKMCI/NAVHOSP BEAUFORT SC//00//
RULSAMS/NAVICP MECHANICSBURG PA//00//
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RUEHJA/NAVMEDRSCHU TWO JAKARTA ID//00//
RUEHEG/NAVMEDRSCHU THREE CAIRO EG//00//
RUWDXGO/NAVPGSCOL MONTEREY CA//00//
RHWIVLF/NAVRADSTA T JIM CREEK OSO WA//00//
RUERGAG/NAVSCSCOL ATHENS GA//00//
RUSKSDE/NAVSECGRUACT NORTHWEST VA//00//
RUQISDE/NAVSECGRUACT SABANA SECA PR//00//
RUETIDA/NAVSECGRUACT SUGAR GROVE WV//00//
RUQOSDE/NAVSECGRUACT WINTER HARBOR ME//00//
RUEGJAI/NAVSHIPYD PORTSMOUTH NH//00//
RHWIPXG/NAVSTA BREMERTON WA//00//
PAGE 04 RUENAAA0534 UNCLAS
RHWIDIS/NAVSTA EVERETT WA//00//
RUCOGCA/NAVSTA GUANTANAMO BAY CU//00//
RHFJFFF/NAVSTA MAYPORT FL//00//
RHFJJXP/NAVSTA PANAMA CANAL RODMAN PM//00//
RULGPRQ/NAVSTA ROOSEVELT ROADS PR//00//
RUFAPUV/NAVSTA ROTA SP//00//
RUFNGSC/NAVSUPPACT GAETA IT//00//
RUFNDFA/NAVSUPPACT LA MADDALENA IT//00//
RUCCFMA/NAVSUPPACT MID SOUTH MILLINGTON TN//00//
RUFNPHB/NAVSUPPACT NAPLES IT//00//
RUCCRAO/NAVSUPPACT NEW ORLEANS LA//00//
RUFBPYG/NAVSUPPACT SOUDA BAY GR//00//
RHEHAAA/NAVSUPPFAC THURMONT MD//00//
RUCTMGB/NAVSURFWARCEN COASTSYSTA PANAMA CITY FL//00//
RUERNWC/NAVSURFWARCENDIV CRANE IN//00//
RULSACW/NAVSURFWARCENDIV DAHLGREN VA//00//
RULSAAH/NAVSURFWARCENDIV INDIAN HEAD MD//00//
RUDJABH/NETC NEWPORT RI//00//
RULSGMQ/NTC GREAT LAKES IL//00//
RUHEMAK/PACMISRANFAC HAWAREA BARKING SANDS HI//00//
PAGE 05 RUENAAA0534 UNCLAS
RHWIDIH/SUBASE BANGOR WA//00//
RHFJKCM/SUBASE KINGS BAY GA//00//
RUEGARA/SUBASE NEW LONDON CT//00//
RUWFBOP/WPNSUPPFAC SEAL BEACH CA//00//
RUWFBOP/WPNSUPPFAC SEAL BEACH DET CONCORD CA//00//
RHFJFNF/WPNSTA CHARLESTON SC//00//
RUDJAMC/WPNSTA EARLE COLTS NECK NJ//00//
RUCOYAO/WPNSTA YORKTOWN VA//00//
INFO RUCBCLF/CINCLANTFLT NORFOLK VA//N46//
RHHMHAH/CINCPACFLT PEARL HARBOR HI//N46//
RHDLCNE/CINCUSNAVEUR LONDON UK//N7//
RULSFAN/COMNAVAIRSYSCOM PATUXENT RIVER MD//AIR-4.0//
RULSSEA/COMNAVSEASYSCOM WASHINGTON DC//04//
RUCTPOA/CNET PENSACOLA FL//01/0S4//
RUENMED/BUMED WASHINGTON DC//033//
RUCCNOM/COMNAVRESFOR NEW ORLEANS LA//N46//
RULSADO/NAVY JAG WASHINGTON DC//35//
RUCOPAW/COMNAVSAFECEN NORFOLK VA//40//
RULSADK/COMNAVFACENGCOM WASHINGTON DC//09/OPS/PC//
RUHEMCW/PACNAVFACENGCOM PEARL HARBOR HI//OPS/HSG/BOS//
PAGE 06 RUENAAA0534 UNCLAS

RUCOBRR/LANTNAVFACENGCOM NORFOLK VA//93/08/16//
RHFJFMC/SOUTHNAVFACENGCOM CHARLESTON SC//09/08/16//
RUWDHLN/SOUTHWESTNAVFACENGCOM SAN DIEGO CA//09/03/05//
BT
UNCLAS //N05100//
MSGID/GENADMIN//
SUBJ/PROCEDURES TO MINIMIZE POTENTIAL CARBON MONOXIDE HAZARDS IN NAVY FAMILY HOUSING//
REF/A/DOC/OPNAVINST 5100.23E/15 JAN 99//
REF/B/DOC/COMNAVSAFECEN MSG R301830Z OCT 98//
REF/C/DOC/COMNAVFACENGCOM MSG R191412Z NOV 98//
NARR/REF A REQUIRES IDENTIFICATION, REPORTING, INVESTIGATION AND CONTROL OF HAZARDS IN NAVAL FACILITIES. REF B ALERTED COMMANDERS NAVY-WIDE OF CARBON MONOXIDE HAZARDS IN HOMES. REF C DIRECTED THE INSTALLATION OF CARBON MONOXIDE DETECTORS IN ALL NAVY OWNED OR LEASED FAMILY HOUSING UNITS.//
RMKS/ 1. INVESTIGATIONS PER REF A INDICATE A NEED FOR ADDITIONAL EMPHASIS TO ENSURE CARBON MONOXIDE (CO) POISONING HAZARDS IN NAVY FAMILY HOUSING ARE UNDERSTOOD, IDENTIFIED, AND CONTROLLED.
2. REF B IDENTIFIED HEALTH EFFECTS AND COMMON SOURCES OF CO. SOURCES
PAGE 07 RUENAAA0534 UNCLAS
OF CO IN FAMILY HOUSING INCLUDE NATURAL GAS/OIL FUEL BURNING SYSTEMS SUCH AS HOT AIR FURNACES, HEATING BOILERS, KITCHEN OVENS AND RANGES, WATER-HEATERS, CLOTHES DRYERS, FIRE PLACES, VEHICLES, AND PORTABLE HEATERS.
3. REF C DIRECTED THE INSTALLATION OF CARBON MONOXIDE ALARMS/DETECTORS IN ALL NAVY OWNED OR LEASED FAMILY HOUSING UNITS WITH NATURAL GAS/OIL FUEL BURNING SYSTEMS.
4. TO FURTHER MINIMIZE RISKS DUE TO POTENTIAL CARBON MONOXIDE HAZARDS IN NAVY FAMILY HOUSING, COMMANDS WITH HOUSING ASSETS SHALL IDENTIFY ALL NAVY FAMILY HOUSING UNITS WITH NATURAL GAS/OIL FUEL BURNING SYSTEMS AND IMPLEMENT THE FOLLOWING PROCEDURES:
A. INSPECT NAVY FAMILY HOUSING UNITS WITH GAS FURNACE INSTALLED WITH MAKE-UP AIR DAMPER IN THE HEATING CLOSET TO ENSURE FUSIBLE LINK IS IN GOOD CONDITION (NOT SEPARATED) AND MAKE-UP AIR DAMPER REMAINS OPEN WHILE IN OPERATION. REPLACE FUSIBLE LINK, AS APPROPRIATE.
B. CONDUCT REVIEW OF ALL NAVY FAMILY HOUSING MAINTENANCE CONTRACTS TO DETERMINE IF NATURAL GAS/OIL SYSTEM MANUFACTURER SPECIFIC MAINTENANCE REQUIREMENTS HAVE BEEN IDENTIFIED, E.G. PERIODICITY OF MAINTENANCE AND SPECIFIC PROCEDURES, AND ARE BEING IMPLEMENTED.
C. CONDUCT REVIEW OF ALL NATURAL GAS/OIL SYSTEM PREVENTIVE AND
PAGE 08 RUENAAA0534 UNCLAS
PLANNED MAINTENANCE (PM) SCHEDULES PRIOR TO EACH HEATING SEASON. REVIEW THE FREQUENCY AND SCHEDULING FOR PM AND DETERMINE IF IT IS CONSISTENT WITH EARLIEST POSSIBLE SEASONAL USE BY THE RESIDENT. REVIEW AND DETERMINE IF THE SCOPE OF PM IS CONSISTENT WITH ACCEPTABLE INDUSTRY PRACTICES.
D. IF PM FORMS FOR NATURAL GAS/OIL SYSTEMS ARE REQUIRED, REVIEW CONTRACTOR SUBMITTALS TO ENSURE THE CONTRACT REQUIRED PM FORMS ARE BEING USED. ENSURE THAT PERSONNEL PERFORMING PM IDENTIFY ANY REPAIR WORK THAT WAS ACCOMPLISHED DURING PM.
E. EVALUATE QUALITY CONTROL PROCEDURES TO DETERMINE IF PROCEDURE CHANGES ARE NECESSARY IN ORDER TO ENSURE THAT PROPER MAINTENANCE PROCEDURES AND FORMS ARE BEING USED FOR NAVY FAMILY HOUSING UNITS.

5. IMPLEMENTATION OF THESE PROCEDURES IS TO BE COMPLETED AND INFORMATION ON THE STATUS OF EACH OF THE ABOVE ITEMS REPORTED TO THE SUPPORTING NAVFAC ENGINEERING FIELD DIVISION BY 16 JULY 1999. THE NAVAL FACILITIES ENGINEERING COMMAND WILL USE THE INFORMATION RECEIVED TO DEVELOP A SUMMARY REPORT FOR SUBMISSION TO CNO N44 BY 13 AUGUST 1999. THIS TIMELINE WILL ALLOW ANY FOLLOW-ON ACTIONS THAT MAY BE REQUIRED TO BE IMPLEMENTED PRIOR TO THE NEXT HEATING SEASON.

6. POC IS LCDR MIKE LIPSKI, CNO N443, AT DSN 664-9998 OR

PAGE 09 RUENAAA0534 UNCLAS

COMMERCIAL (703) 604-9998.//

BT

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DEPARTMENT OF THE NAVY **NFGS-13856**
NAVAL FACILITIES **24 May 1999**
ENGINEERING COMMAND
GUIDE SPECIFICATION

****

SECTION 13856

CARBON MONOXIDE DETECTORS
01/99

****

NOTE: This guide specification covers the requirements for carbon monoxide alarm detectors for protection in indoor locations of living quarters where fuel-burning appliances/equipment are used.

****

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

UNDERWRITERS LABORATORY INC. (UL)

UL 2034	(1996; R 1997) Single and Multiple Station Carbon Monoxide Alarms

1.2 SUBMITTALS

****

NOTE: The "G" in submittal tags following a submittal item indicates Government approval and should be retained. Add "G" in submittal tags following any added submittals. Submittal items not designated with a "G" will be approved by the CQC organization.

****

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-03 Product Data

Carbon monoxide detector

SD-06 Test Reports

Carbon monoxide detector test

[SD-10 Operations and Maintenance Data

Carbon monoxide detector; Data Package 1

Submit operation and maintenance data in accordance with Section 01781, "Operation and Maintenance Data".

]PART 2 PRODUCTS

2.1 CARBON MONOXIDE DECTECTOR

UL 2034, [Single station] [Multiple station] detector [surface] [flush] mounted. Operational requirements shall be as follows:

a. Electrical: [120 Volt AC with 9 volt battery backup] [volt DC]

b. Environmental: minus 40 degrees to 150 degrees F and 15 to 93% relative humidity.

c. Response time: [12 minutes] [ ] at [400] [ ]ppm of carbon monoxide detected.

****

NOTE: Corps of Engineers EM-385-1-1, Safety and Health Requirements Manual has specified that air shall not contain a level of carbon monoxide greater than 20 ppm.

****

d. Alarm Trigger: Audible and visual signal to indicate a gas concentration in excess of 70 ppm carbon monoxide for one hour.

e. Alarm and Indicator: Red LED for visual and 85 db at [10][ ] ft for audible alarm. Malfunction indicator light shall be yellow LED.

2.2 CONDUIT, BOXES, AND FITTINGS

****

NOTE: The second bracketed option is the short form version of the interior electrical and its use is at the discretion of the Engineer/Architect in charge.

****

Specified in Section [16402, "Interior Distribution System"] [16110, "Interior Electrical Work"].

2.3 WIRES AND CABLES

****

NOTE: The second bracketed option is the short form version of the interior electrical and its use is at the discretion of the Engineer/Architect in charge.

****

Specified in Section [16402, "Interior Distribution System,"] [16110, "Interior Electrical Work"].

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Electrical work

Electrical installation shall conform to the requirements of Section [16402 "Interior Distribution System"] [16110, "Interior Electrical Work"], and NFPA 70

3.1.2 Carbon Monoxide Detector

Install detector[s] in accordance with the manufacturer's instructions. Provide detector in hallway outside bedroom[s], [ ], and in location[s] as indicated.

3.1.3 Grounding and Bonding

Equipment grounding and bonding shall be in accordance with UL 2034and NFPA 70

3.2 FIELD QUALITY CONTROL

Provide test equipment and personnel and submit written copies of the test results. Notify Contracting Officer [15] [ ] working days prior to the test.

3.2.1 Carbon Monoxide Detector Test

Contractor shall show by demonstration in service that the detector[s] [is][are] in good condition and properly performing the intended function. Test shall be in accordance with UL 2034 requirements specified in paragraph entitled "Normal Operation Test" [and the manufacturer's test procedure].

****

NOTE: Suggestions for improvement of this specification will be welcomed using the "Agency Response Form" located in SPECSINTACT under "System Directory" or DD Form 1426. Suggestions should be forwarded to:

Commanding Officer
Seabee Logistics Center
NAVFAC 15G/SLC 15E
4111 San Pedro Street
Port Hueneme, CA 93043-4410

FAX: (805) 985-6465/982-5196 or DSN 551-5196

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Combustion Air and Venting -- No Trivial Matter

By Lyle H. Grant, CIPE, DES

Often plumbing contractors get involved with combustion air requirements such as when installing a gas or oil fired water heater. When the installation for such an appliance is part of an architectural plan and specification, the combustion air provisions are usually included in the sheet metal work. This tends to minimize the plumbing contractor's involvement in this very important aspect of the work and, consequently, tends to decrease the awareness plumbers must have regarding the importance of sufficient combustion air provisions. Coupled with this is the general tendency to overlook combustion air requirements in common everyday water heater change-outs on the premise that "it's worked OK for twenty years; why make a problem of it!" The fact is, such a "trouble free" installation may have been only marginally safe for all the years it was in service and any small change as a result of the new installation could be enough to create a serious venting problem. The balance between a marginally safe venting system and a dangerously ineffective system can be tipped disfavorably by the slightest of changes. Venting problems are nothing to trifle with. Neglecting to correct a venting problem can result in asphyxiation or, at best, a very unhealthy environment.

Safe venting has its fundamentals in two things: sufficient combustion air provisions and the adherence to proper venting principles. These two entities are so closely related that one cannot be thought of without the other. A safe venting system cannot be attained without sufficient combustion air. But, most assuredly, neither can it be attained if proper venting principles are not applied. Combustion air is a fairly straightforward subject, at least as it applies to the small appliances treated in this article. Venting, on the other hand, is a very involved subject whether dealing with a single appliance or a complex system of multiple appliances. Any in-depth analysis into the complexities of venting is beyond the scope of this article. Instead, we will try to blend a little venting theory with a little of the practical to come up with some insights to help keep our venting systems safe. Any and all references to the subject of venting throughout this article shall pertain to natural draft venting of conventional "80%" efficient water heaters or small appliances.

Combustion and combustion air

When a fossil fuel such as a manufactured (LP) gas, natural gas or oil is mixed with the proper amount of air and the mixture is raised to a certain ignition temperature, an exothermic (heat releasing) chemical reaction takes place between the carbon and hydrogen molecules in the fuel and the oxygen molecules in the supplied air. This supplied air is necessary for the chemical reaction to take place and is only one of the three things provided by combustion air. The other two constituents of combustion air are dilution air (treated later in the article) and ventilation air, which is needed for the dissipation of heat from a confined appliance room. The exothermic reaction is called the process of combustion and the chemical exchange that takes place is different for each chemical that is burned. When wood is burned, the by-products of combustion are different than when oil is burned; and when oil is burned, the by-products are different from that of natural gas, and so it goes for each compound and element in existence when they undergo the process of combustion. Some materials give off toxic fumes when they are burned and have restrictions on their usage in buildings. For our purposes in this article, however, it is only important to know that the by-products common to all efficient fossil fuel combustion reactions are heat, light, water (in a vapor state) and carbon dioxide (CO2).

If sufficient combustion air is not supplied, there will be a deficiency of available oxygen and the lethal gas carbon monoxide (CO) instead of carbon dioxide will be formed during the combustion process. Now here is the "Catch-22" -- because combustion air is also a major factor in the evacuation of flue gas to the outside atmosphere, as we will see later, the shortage of it, which caused the build up of CO in the first place, now restricts the safe evacuation of the CO-laden flue gas up the chimney. The inability of the flue gases to rise up the chimney causes them to accumulate and, hence, to further displace any combustion air that may be available thus causing an even further build up of CO. And so the cycle is repeated until the CO builds up to a lethal concentration.

Normally, when we breath air into our lungs, oxygen molecules are transferred to our blood and are carried by the red blood cells to all the vital tissues of our body, including the brain and heart which are especially dependent on a continuous supply of oxygen. The red cells are able to do this because they contain millions of molecules of a substance called hemoglobin which has a strong affinity, or attraction, for the oxygen molecule. The problem is, this very same hemoglobin has an even stronger affinity for the carbon monoxide molecule -- in fact, over 200 times as strong. When CO is inhaled, the hemoglobin binds the CO molecules instead of the oxygen molecules and carries the CO to the body's tissues. The result is a complex chemical breakdown of the body with the brain and heart being especially vulnerable. The biochemistry of this breakdown is beyond the scope of this article. All we have to know is that the effects are swift and deadly -- all because of insufficient combustion air.

Combustion air sources

Ideally, combustion air should be obtained from outside air sources via ductwork or exterior wall openings. If the space in which the water heater or appliance is located has sufficient infiltration of outside air by virtue of leakage around windows, doors and unsealed cracks and, in addition, has adequate volume of space, then and only then combustion air may be taken from the surrounding space unless instructed otherwise by the manufacturer's installation book. If it is determined there is adequate infiltration of exterior air, then it must be determined that there is adequate volume of space from which to draw the combustion air. Most building codes require a minimum of 50 cubic feet of volume for every 1000 btuh input of all appliances involved that are gas- or oil-fired. The key words to remember when using interior spaces for a combustion air source are "sufficient infiltration" and "adequate volume of space." Both properties must exist before any notion of drawing combustion air from the interior space in question is entertained. If the appliance is located in a closet or enclosure in which wall openings or grilles are used to draw combustion air from a space having adequate volume, it is vitally important that one such opening is located in the upper part of the closet and the other opening located near the floor. This high/low arrangement of combustion air openings provides the necessary circulation to prevent carbon monoxide build-up in the closet or enclosure should the venting system become blocked and is required whether the combustion air is taken from interior spaces or directly from outside. Local code authorities should be consulted regarding the size of openings required for each application.

Having a space volume that mathematically meets the 50 cu.ft./ 1000 btuh input rule does not necessarily mean such surrounding space can be used as a source of combustion air. If the construction of the building falls into an "exceptionally tight" category (as defined in the various building codes), infiltration cannot be relied upon to provide sufficient combustion air even though the "volume rule" may be satisfied. Under these conditions, combustion air must be obtained from the outdoors or from spaces freely communicating with the outdoors.

The quality of the air used for combustion air purposes must also be considered. Neither areas in which flammable or volatile solvents are used or stored nor areas where dusts, fumes or particulates are generated can be used as sources of combustion air. Drawing combustion air from such hazardous areas can result in an explosion or, at best, rapid heat exchanger deterioration of the appliance and associated vent piping. Laundry rooms cannot be used for a combustion air source because of the fumes from detergents, bleaches, softeners and other chemicals used for laundering, which are all very corrosive and detrimental to the heat exchanger and vent piping.

Venting

A venting system is a series of connected pipes and passageways for conveying combustion flue gas to the outside atmosphere. This does not occur automatically merely by connecting a series of pipes together which terminate somewhere through a roof. Quite the contrary. There are many scientific principles involved in proper vent system design, not the least of which is the use of certain materials installed in a certain way. Fortunately, there are listed (laboratory tested and certified) vent system piping and components manufactured and available for virtually every type of fuel and application.

Accompanying these listed systems should be manufacturer's installation instructions and sizing tables. Be sure to get these tables and directions when you purchase the vent piping. A safe venting system simply cannot be installed without following these tables. Were it not for this supplied information, the system designer or installer would have to laboriously calculate piping pressure drops, heat transfer coefficients of various materials, flue gas temperatures and flue gas densities, all in order to attain a properly operating system. All of these factors are built into the vent sizing tables of a listed system.

The only reason flue gases rise in any gravity venting system is because they are hot and, thus, lighter than the surrounding air. This density (weight) difference gives them a buoyant property much like a floating cork in the much more dense water. The surrounding cooler (heavier) air dropping downward around the appliance "pushes" the hot flue gas upward inside the vent stack or chimney. The difference in weight between a given volume of hot flue gas inside the stack and an equal volume of the heavier surrounding air is the "power" afforded to force the flue gases upward.

This power -- called draft -- is of such a small degree it is measured in hundredths of inches water column pressure -- a very small force considering that 1" W.C. = 0.036 pounds per square inch (psi). In terms of psi, draft power would have to be measured in the ten thousandths of a psi. Flue gas analysis and research has shown that for a conventional gravity vented 100,000 btuh input gas-burning furnace, more than 200 pounds of flue gas must be conveyed (pushed) up the vent stack or chimney, along with more than a gallon of water in a vapor state, every hour -- a lot of work expected from a force measured in ten thousandths of a psi.

The heavier surrounding air, which is a major factor in the evacuation of the flue gas up the stack, is provided in the form of sufficient combustion air. From this we see how very important combustion air is. Not only does it keep CO to a minimum, it also is necessary for safe venting.

Connector piping

The pipe that connects an appliance draft hood to a chimney or vent stack is called a connector pipe or, simply, a connector. Single wall galvanized steel is commonly used for connector pipe for both gas- and oil-fired appliances though it is not recommended for gas-burning appliances. Listed double wall B-vent should be used for gas burning appliance connector piping to reduce the risk of cooling the flue gases and, thus, losing the buoyancy which causes them to rise.

Because vent connector piping gets nearly as hot as the flue gas it is conveying, maintaining safe clearances to combustible material is very important. If single wall galvanized steel pipe is being used as a connector for a gas-burning appliance with a draft hood (which lowers flue gas temperature somewhat), the absolute minimum clearance to combustibles is 6 inches. For an oil-fired appliance, which has much higher flue gas temperatures, a minimum clearance of 18 inches is required. This clearance can be reduced somewhat if a heat shield of at least 28 gauge sheet metal is incorporate with a minimum 1-inch air space between the combustible and the sheet metal shield. Local codes should be consulted for reduced clearance requirements when incorporating a heat shield. If listed piping is used for a connector, then the clearances as stamped or marked on the piping must be followed. Using listed B-vent for a gas appliance connector pipe is recommended for any installation, but it is mandatory to use it if the connector is running through a cold crawl space or if there is a problem with keeping the flue gases hot enough to maintain their buoyant properties. Under no circumstances can B-vent be used for an oil-fired appliance. The much higher flue gas temperatures of an oil-fired appliance will destroy the inner, aluminum wall of a B-vent.

Connector piping is a very important part of a venting system and, if not installed correctly, can cancel out everything that has been done correctly. For example, not providing enough vertical rise off the appliance draft hood before incorporating an offset fitting puts too much restriction on the flow of flue gases causing them to build up and spill back out of the draft hood (see Fig. 1). The more vertical connector pipe rise before an offset the better, but certainly not less than 12 to 14 inches.

Even with sufficient vertical rise and sufficient combustion air, poor venting can still occur if the lateral portion of a connector is too long or if it does not have sufficient slope upward toward the vent stack or chimney.

Excessively long single wall connectors lose too much heat, allowing the flue gases to cool and lose their buoyancy. Likewise, if there isn't sufficient upward slope toward the vent stack or chimney, the flue gas is trapped by the flatly installed pipe -- just like holding your hand over a submerged cork preventing it from rising to the surface. The more slope, the better; but certainly not less than 1/4 inch per foot slope upward toward the chimney or vent stack is required or draft hood spillage will most assuredly occur (see Fig. 1).

Vent manufacturers' sizing tables must be consulted for proper connector pipe sizing, especially when long lateral runs are involved. Long lateral connectors significantly reduce the carrying capacity of a vent system and it is imperative to make use of these tables or get manufacturers' input directly. The risk and liability is too great to rely on guesswork when sizing any kind of vent system piping.

Vent stacks and chimneys

A vent stack, generally, is a listed manufactured double walled or insulated pipe to which one or more connectors are tied into for the conveyance of flue gas to the outside atmosphere. Listed vent stacks are usually found in newer buildings while brick and masonry block chimneys will be found in older buildings. Vent stacks should run in a vertical plane with no offsets. Lateral offsets of any length in a vent stack significantly reduce the btuh carrying capacity of the system. Where offsets are unavoidable, vent manufacturers' sizing tables must be carefully followed. If the offset is exceptionally long and beyond the allowable length listed in the sizing tables, do not rely on luck in thinking that it will work. Again, don't take risks when it involves venting -- the liability and consequences are too great to rely on guesswork or false hopes that the system will somehow work properly. As much slope as possible should be given to any lateral section of vent piping but, in no case, should the slope upward (toward the roof termination) be less than 1/4 inch per foot.

Listed vent stack systems work well when installed in accordance with the terms of listing, i.e., the manufacturer's directions. In those listed systems where problems occur, it is most often because of one of the following:

* Insufficient combustion air.
* Improper sizing.
* Insufficient slope.
* Fireplaces or exhaust fans causing negative pressure.

Manufacturers thoroughly cover all of the above improprieties in their accompanying installation manuals except, perhaps, for the fourth item. This very dangerous condition is often overlooked. One of the worst multiple asphyxiation cases I've seen involved a fireplace chimney whose natural draft was so great that it literally pulled flue gases back down the vent stacks serving various other appliances throughout the building. The toxic gas migrated through occupied areas, including the lounge and bedrooms, asphyxiating eight people.

Attic fans and exhaust fans can do the same thing. Any equipment that can put a building or house under negative pressure must be considered in combustion air and venting system design. Along those same lines is the very dangerous condition of having a return air register of a forced warm air system too close to an appliance vent. This lethal arrangement is often found in basement return duct systems next to vented appliances. When the furnace blower fan is in operation, it will pull flue gas down the vent and into the furnace return air stream thus distributing flue gases throughout the occupancy. A separation of 10 feet between any return air opening and a flue gas vent is considered an absolute minimum distance. Ill-fitting or open return air duct joints can also pull flue gas into the air distribution system in a similar manner as a return register, so care must be exercised to make sure all such joints are sealed properly.

Nothing one can say regarding combustion air or venting is more important than another; it is all very much linked together. Although manufacturers give very explicit directions in their installation booklets, these very important directions, unfortunately, are often not read or followed. This total lack of responsibility is not merely asking for serious trouble, it is begging for it.

Dealing with heavy mass

When dealing with heavy mass brick or masonry block chimneys, the installer must rely upon the appliance manufacturer's recommendations and jurisdictional code requirements for venting into such unlisted systems. Chimneys of this type are prone to condensation and spillage problems, especially in colder climates. A commonly found situation is one where a conventional gas furnace and gas water heater are both tied into a brick (or heavy mass) chimney and the owner wishes to switch to a new high efficiency furnace. This being done, the PVC flue pipe from the new furnace is vented through an outside wall leaving only the nominal 3-inch or 4-inch diameter connector from the water heater tied back into the chimney. This is specifically warned against in water heater manufacturer's installation directions; but, nevertheless, it is done all too often and usually with serious consequences. The heavy mass of the chimney absorbs heat from the water heater's flue gas on the way up the chimney. If the chimney is high enough and/or cold enough, the flue gases will cool and lose their buoyancy only to drop back down the chimney and spill at the draft hood. In addition, the entrained water vapor in the flue gas, having been cooled to dewpoint temperature, now condenses on the inner walls of the chimney causing serious deterioration. Chimney walls do not have to be exceptionally cold for this to happen, merely at the dewpoint temperature of the saturated flue gas which, for a conventional gas appliance or water heater, averages around 127 degrees

Fahrenheit. This means the chimney mass temperature has to be at least 127 F or more to prevent condensation. Further, if sufficient combustion air is not provided in the form of dilution air at the draft hood, the flue gas dewpoint will be even higher -- upwards to 140 F. In this case, unless the entire chimney mass temperature is maintained at 140 F or more, condensation will occur.

If the chimney has a clay tile or stainless steel liner, condensation can still occur if the outside temperature is low enough or if the chimney has its wall surfaces exposed to the exterior. Many older buildings have chimneys running up an outside wall with three or more exposed surfaces. These are the types most vulnerable to condensation problems. A clay tile or stainless steel liner will offer little protection against condensation because such liner material has little insulative value and will allow the flue gases to cool. The solution is to provide an insulated or double-wall liner that is listed for the application and for the type of fuel used.

Venting problems associated with heavy mass chimneys are much more prevalent with gas-fired appliances. Oil-fired appliances are a little more forgiving in this respect because their flue gases are hotter and are able to expend more heat to the cold chimney walls before reaching their dewpoints. But, again, if the chimney has enough mass and/or the outside temperature is low enough, condensation problems can occur with oil-fired appliances as well.

Many old masonry chimneys have built-in offsets making it impossible to drop a conventional liner or B-vent. There are listed flexible liners for these problem applications, but they cannot be sized using conventional vent sizing tables because flexible liners have less btuh carrying capacity. Listed flex liners have their own sizing tables that are derated to allow for the added resistance of their corrugated walls, the added surface area of the corrugations, and the inability to keep the flue gas as hot for a given length due to their single wall construction. The appropriate derated sizing tables accompanying the flex liner must be followed. Most flex liners are made of aluminum and are listed for gas appliances only, but there are some constructed of heavy gauge stainless steel and listed for oil-burning applications. Be sure to use the correct one.

Conclusions

1) The importance of adequate combustion air cannot be overemphasized; without it, the best designed and installed venting system will not work properly.

2) The tightness of the building must be determined to know if interior spaces can be used as a source of combustion air or if it must be obtained directly from the outdoors. Don't be too quick to assume a building has adequate infiltration to permit usage of interior spaces as a combustion air source. New and remodeled buildings nowadays are constructed to such a degree of tightness that infiltration cannot be relied upon for combustion air purposes.

3) It is extremely important that attic fans, exhaust fans, fireplaces, and other equipment tending to put the building under negative pressure be taken into consideration in combustion air and vent system design. Also make sure there are no return air registers, grilles or openings nearby which could pull

flue gas down a vent into an air distribution system or forced warm air system.

4) Make sure all vent connectors and vent stacks are sized correctly and have adequate upward slope.

5) Avoid offsets and long lateral runs in vent stacks and/or connector piping. If offsets are unavoidable, follow the manufacturer's appropriate sizing tables for laterals.

6) Do not vent into heavy mass masonry chimneys without a proper liner, especially with gas-burning appliances and in colder climates.

7) Never leave a jobsite installation without doing a draft check on all appliances as shown in Fig. 2. If multiple appliances are involved, check each one individually (with the burner on), then put all the appliances in operation with all their burners on and proceed to check each one individually again. This is a good test to show if there is any backspillage (where one drafts but spills back through another instead of going up the vent) among any of the appliances.

It is my hope that none of us will ever be involved in an asphyxiation case resulting from something we installed; but, at the same time, we must be aware of the possibility and that we must always be vigilant. Do not rely on chance when it comes to combustion air or venting. If this article, in some small way, compels us to this realization, it will have served its purpose. [END]

About the Author

Lyle H. Grant, CIPE, has 24 years experience in building system and related fields, much of it with consulting firms specializing in institutional and commercial work. He is a state-licensed Designer of Engineered Systems (HVAC) in Wisconsin, a member of ASPE and associate member of ASHRAE. Holding both IAPMO and ICBO certifications, Mr. Grant is a mechanical and plumbing inspector for the City of Dubuque, Iowa.

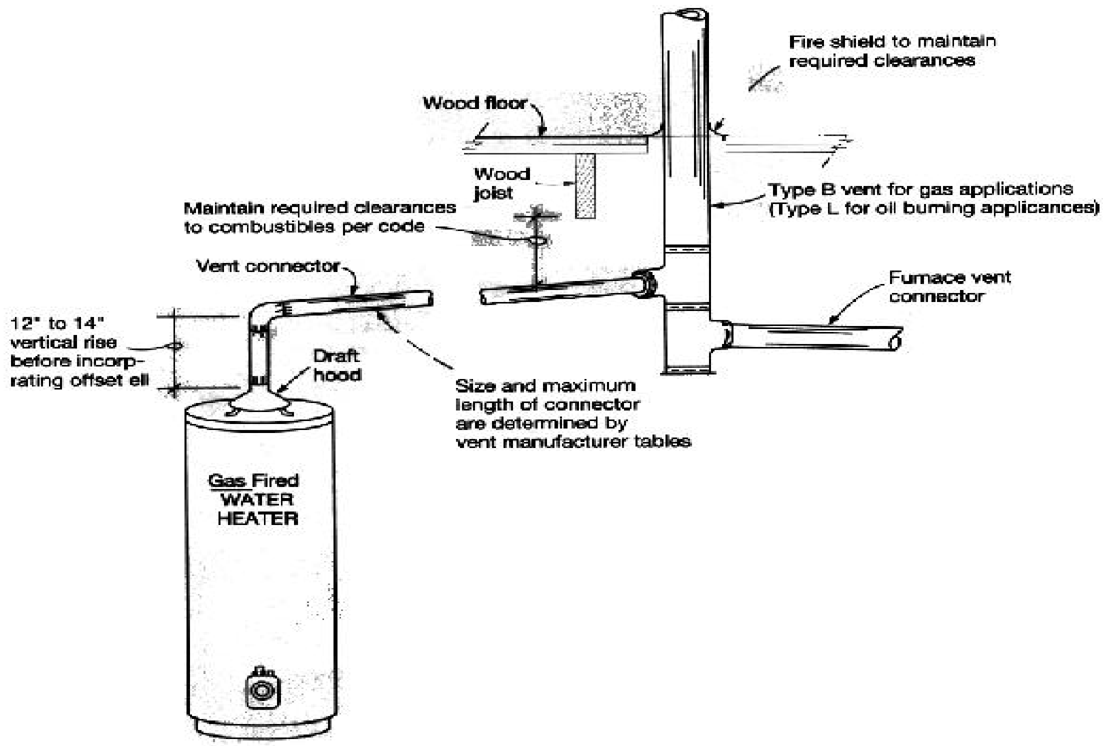

Figure 1 — Connector piping is a very important part of a venting system. If not installed correctly, it can cancel out everything that has been done correctly.

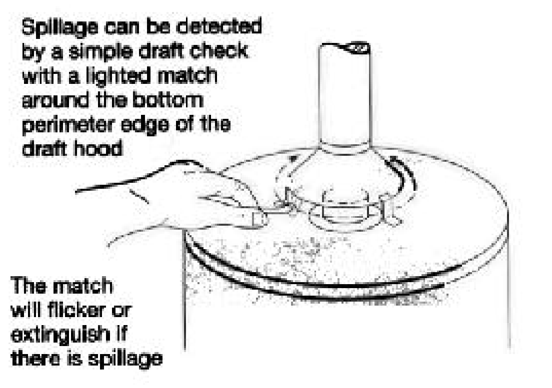

Figure 2 — Never leave a jobsite installation without doing a draft check on all appliances, both singly and together, with the burner(s) on.