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COURSE 962912

Weatherization Guide - Chapter 5

Review Material

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Summary Of This Course

WEATHERIZATION GUIDE - CHAPTER 5

Approved by the

Wisconsin Department of Safety and Professional Services Safety and Buildings Division
Course Identification Number 962912
Educational Credit Hours: 6 Hours

Course Provider:
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Chapter 5 of the Weatherization Guide emphasizes protecting both occupants and weatherization professionals by identifying and controlling health and safety hazards before, during, and after weatherization work. The chapter covers the proper use of personal protective equipment (PPE), Safety Data Sheets (SDS), confined-space procedures, and source pollutant control. Major topics include carbon monoxide testing and alarm installation, smoke alarms, moisture management, foundation moisture control, lead-safe work practices, asbestos awareness, and electrical safety. It also provides detailed procedures for inspecting gas piping, monitoring ambient carbon monoxide, performing combustion appliance safety testing, measuring draft, and evaluating depressurization in combustion appliance zones. Guidance is included for make-up air systems, water heater replacement, and selecting, sizing, installing, and maintaining mechanical ventilation systems in accordance with ASHRAE 62.2. The chapter concludes with best practices for dryer venting and radon mitigation measures, including proper sump sealing techniques.

This Course is approved for the following electrical Registrations/Certifications or Licenses:

Dwelling Contractor Qualifier	6 Hours of Continuing Education	
Commercial Building Inspector	6 Hours of Continuing Education	

This course is a distance learning or e-learning course, which allows the attendee to complete the course on their time schedule.

Course Outline

This course is a distance learning or e-learning course, which allows the attendee to complete the course on their time schedule.

5.14 Priorities for Existing Homes

5.14.1 Installation Best Practices

5.15 Radon

5.15.1 Sumps

5.15.2 Sump Pumps

5.15.3 Sump covers for submersible pumps

5.15.4 Sump covers for pedestal pumps

5.15.5 Floor Drains

180 questions related to the reference materials are used to test the attendee on their comprehension of the materials. A 70% score will need to be attained in order to pass this course.

Answer Sheet(s)

1 bubble style answer sheets are included. When you are finished with the exam, you may return the answer sheets for grading to:

By Mail: Uscontractorlicense LLC
PO Box 268
Platteville, Wisconsin 53818

By Email: michael@uscontractorlicense.com

By Fax: 608-571-0096

Once we get the answer sheets back, we will graded them, enter your hours into the attendance portal and email or mail you back your certificate of completion(s). You will be responsible for renewing your license with the DSPS at www.license.wi.gov website.

Any questions, please contact us at 608.348.6688

Foreword

The Wisconsin Weatherization Field Guide is a comprehensive guide to installing weatherization measures and verifying the quality of the work. The Field Guide is a tool for crew workers, energy auditors, and inspectors. The program's policies and administrative practices are identified in the Wisconsin Weatherization Program Manual.

The Field Guide started with dedicated weatherization crew workers determined to improve their trade and the services provided to their customers. It evolved from there to documenting those practices to share them with the rest of the weatherization network. The original Wisconsin Weatherization Field Guide was produced through a collaboration of the 2005 Weatherization Technical Advisory Group, Slipstream (*formerly Wisconsin Energy Conservation Corporation (WECC)*), and Saturn Resource Management.

Wisconsin is one of the national leaders in the Weatherization Assistance Program, and this guide represents the ongoing effort to continually improve our practices and procedures to deliver the best product to our customers.

Credits

Information in *Chapter 5 – Sections 5.15.1, 5.15.2, 5.15.3, 5.15.4, and 5.15.5* is used with permission from *the WAP Precautionary Radon Mitigation Field Guide* by Dick Kornbluth, Dick Kornbluth, LLC, Copyright 2018, Section 11 – Sumps; Pages – 18-22.

The original document was developed in 2005 through collaboration between Wisconsin Division of Energy Services, Slipstream (*formerly Wisconsin Energy Conservation Corporation (WECC)*), Saturn Resource Management, the Technical Assistance Group (TAG) and various technical consultants.

Chapter 5: Health and Safety

This chapter addresses some of the most pressing health and safety hazards households face, as well as those faced by weatherization professionals while auditing, installing measures, or inspecting completed work. When serious safety problems are discovered in a home, field staff should inform an immediate supervisor and the customer about the hazards. Major hazards and potentially life-threatening conditions should be corrected prior to weatherization work beginning unless the installers are making the corrections as part of their work.

See the *Health and Safety Inspection Checklist* and the *Release of Liability Form* located on the Home Energy Plus Training and Technical Assistance (HE+ TTA) website under Weatherization | Forms.

Weatherization workers should be aware of the potential causes of on-site injuries and how awareness and precautions can reduce them. Examples of potential causes include, but are not limited to:

- ✓ Slips, trips, and falls
- ✓ Extreme temperatures
- ✓ Improper tool use
- ✓ Combustibles (materials or gases)

If an emergency occurs in the field, follow the agency safety policy or dial 911. When working, weatherization professionals must follow all applicable health and safety protocols per Occupational Safety and Health Administration (OSHA) and/or the local jurisdiction having authority.

Before beginning work, assess work areas for health and safety hazards to the workers and to the customer. Resolve any hazards either before work begins or during the work process. If hazards cannot be resolved, the home may require deferral until the hazards are addressed.

Inspect all tools for safety and use in accordance with manufacturer's specifications.

5.1 Personal Protective Equipment

On almost a daily basis, weatherization workers find themselves in situations that necessitate the use of personal protective equipment (PPE). The employer is required to provide workers with proper PPE needed to complete their jobs.

Examples of such PPE include, but are not limited to:

- ✓ Disposable coverall garments
- ✓ NIOSH approved respirators with annual fit test (and medical documentation, if required)
- ✓ Eye and face protection

- ✓ Confined-space supplied air and ventilation
- ✓ Hearing protection
- ✓ Fall protection

5.2 Safety Data Sheet (SDS)

The SDS for a product or material contains data about material specifications and safety information. This includes information about:

1. Product and company/manufacturer
2. Hazards identification
3. Composition and ingredients
4. First aid
5. Firefighting
6. Accidental release
7. Handling and storage
8. Exposure controls and personal protection
9. Physical and chemical properties
10. Chemical stability and reactivity
11. Toxicological effects
12. Ecological information
13. Disposal
14. Transport considerations
15. Regulatory information
16. Other

All SDS for weatherization products can be accessed through the Home Energy Plus Training and Technical Assistance (HE+ TTA) website. When possible, materials that create long-term health risks for the customer and workers should be replaced with materials that present less risk.

5.3 Confined Spaces

Weatherization professionals commonly work in small spaces such as crawl spaces and attics that can be defined by OSHA as a confined space. A confined space is large enough and so configured that an employee can bodily enter and perform assigned work but has limited or restricted means for entry or exit and is not designed for continuous employee occupancy.

A sign shall be posted at the entry of the crawl space access including the installers contact information along with any pertinent information related to the work completed.

All work performed within a confined space shall be performed in accordance with OSHA standard 29 CFR Part 1926 Subpart AA Final Rule.

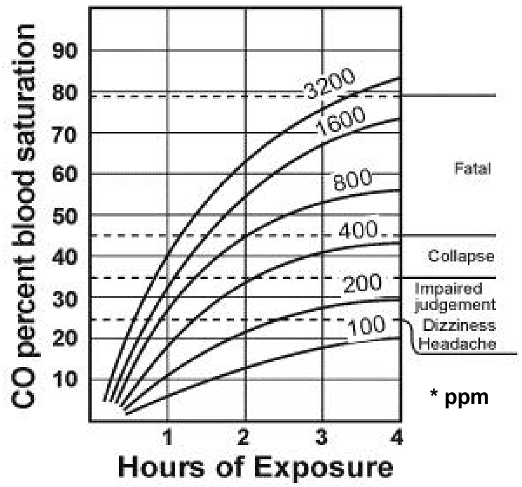
5.4 Source Pollutant Control

The control of pollutants at the source is always the best solution, especially in homes with a lower measured CFM_{50} reading. Whole-building mechanical ventilation helps remove and dilute low levels of pollutants. Technicians should be mindful of pollutant sources and exposures while performing weatherization.

The customer has significant control over the introduction and spread of many home pollutants. Always provide education to the customer about corrective actions they can take to minimize pollutants in their homes.

5.4.1 Carbon Monoxide (CO)

The EPA's suggested maximum eight-hour exposure limit for CO is nine parts per million (ppm) in room air. CO at or above nine ppm is often linked to malfunctioning combustion appliances within the living space.



Effects of CO: This graph's curves represent different exposure levels in parts per million (ppm).

Sources of Carbon Monoxide

CO pollution is often linked to unvented combustion appliances, backdrafting combustion appliances, gas ranges, charcoal grills, and motor vehicles idling in attached garages or near the home.

Testing for Carbon Monoxide

The most common CO testing instrument is an electronic sensor with a digital readout in parts per million (ppm). The readings will be either *AS MEASURED* or *AIR FREE.* Follow the manufacturer's recommendations on zeroing the meter — usually by exposing the meter to outside air. CO testing equipment typically requires recalibration every six months, using factory-specified procedures.

A CO test is normally completed in the appliance exhaust flue or at the exhaust port of the heat exchanger. Elevated CO can be caused by any of the following:

1. Overfiring of an appliance — too much combustion fuel is supplied to the appliance. A low O_2 percentage on a combustion analyzer indicates the appliance may be overfiring. Technicians may determine if the appliance is overfiring by clocking the gas meter.
2. Inadequate combustion air — occurs when a combustion appliance is lacking sufficient combustion air.
3. Backdrafting/spillage of combustion gases suppressing the flame.
4. Flame interference by an object (a pan over a gas burner on a range top, for example).
5. Misalignment of the burner.

Appliance service technicians should strive to identify and correct these problems.

5.4.2 Carbon Monoxide (CO) Alarms

Follow these instructions when installing CO alarms:

1. Install according to the manufacturer's instructions. Leave the manufacturer's instructions with the customer.

2. Educate the customer about the purpose and features of the alarms including what to do if the alarm sounds.
3. Batteries must be internal, non-replaceable, and have a 10-year manufacturer's warranty.
4. Install a CO alarm (if none are present, existing are non-functional, or existing are at least 10 years old), per NFPA 72:
   a. On the ceiling in the same room as permanently installed fuel-burning appliances.
   b. Centrally located on every habitable level and in every HVAC zone of the building.
   c. Outside of each separate dwelling unit, within 21 ft of any door to a sleeping room.
   d. Other locations where required by applicable local code.

Do not install CO alarms:

- ✓ In a room that may get too hot or cold for the alarm to function properly.
- ✓ Within 5 feet of a combustion appliance, vent, or chimney.
- ✓ Within 5 feet of a storage area for vapor-producing chemicals.
- ✓ Within 12 inches of exterior doors and windows.
- ✓ Inside of a furnace closet or room.
- ✓ With an electrical connection to a switched circuit.
- ✓ With a connection to a ground-fault interrupter circuit (GFCI).
- ✓ Behind furniture or appliances.

The manufacturer's instructions may specify stricter standards than these. If a conflict exists, follow the stricter specification.

5.4.3 Smoke Alarms

Follow these instructions when installing smoke alarms:

1. Install according to the manufacturer's instructions. Leave the manufacturer's instructions with the customer.
2. Educate the customer about the purpose and features of the alarms including what to do if the alarm sounds.
3. Batteries must be sealed, non-replaceable and have a 10-year manufacturer's warranty.
4. Install a smoke alarm (if none are present, existing are non-functional, or existing are at least 10 years old) on each floor, including the basement, and in the vicinity of sleeping area(s).

Do not install smoke alarms:

- ✓ Within 12 inches of exterior doors and windows.

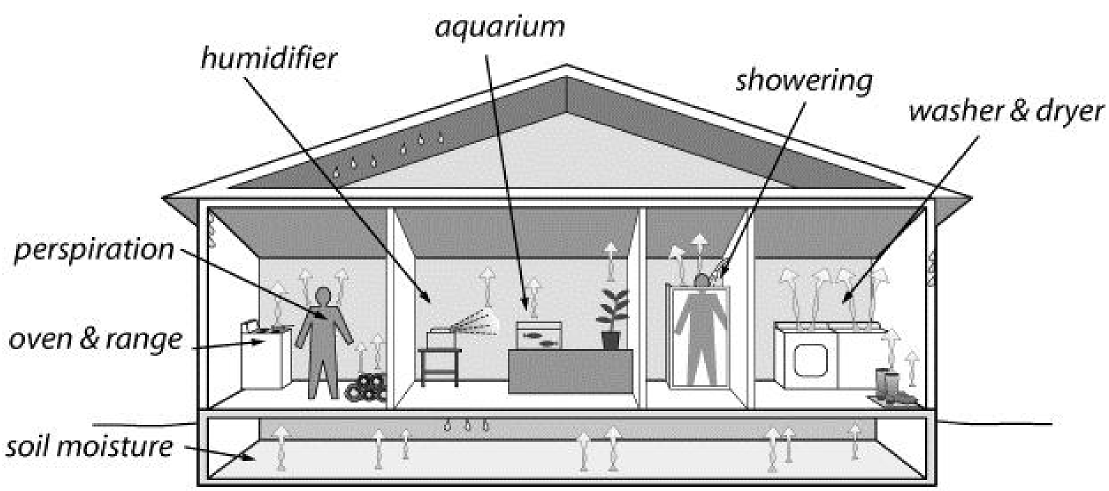
- ✓ On a switched circuit, if hard-wired.
- ✓ On a ground-fault interrupter circuit (GFCI).

The manufacturer's instructions may specify stricter standards than these. If a conflict exists, follow the stricter specification.

5.4.4 Moisture Problems

Water and water vapor damages building materials by promoting mold and rot, dissolving glues and mortar, corroding metal, and nurturing pests like termites and dust mites. These pests, in turn, cause many cases of respiratory distress.

Water and moisture reduce the thermal resistance of insulation and other building materials. The most common sources of moisture are leaky roofs and damp foundations and basement floors. Other critical moisture sources include unvented dryers, showers, cooking appliances, and unvented gas appliances like ranges or decorative fireplaces.



Moisture sources: Household moisture can often be controlled at the source by informed and motivated customers. Indoor relative humidity should be between 30-50 percent.

Identifying and reducing sources of bulk/liquid moisture is the first priority for solving moisture problems. The next priority is to install or repair air and vapor barriers to prevent moisture from migrating into and through building cavities. Local exhaust fans located in the kitchen and bathrooms will remove high levels of moisture and other pollutants at the source.

Table 5-1: Moisture Sources and their Potential Contributions

Moisture Source	Potential Amount Pints
Ground moisture	0-105 per day
Seasonal evaporation from materials	6-19 per day
Dryers venting indoors	4-6 per load

Moisture Source	Potential Amount Pints
Dishwashing	1-2 per day
Cooking (meals for four)	2-4 per day
Showering	0.5 per shower

Relative humidity (RH) is a measurement of the degree to which air is saturated with moisture. Air at 100 percent RH is completely saturated. Home air below 30 percent RH is uncomfortably dry for many people. Air above 50 percent RH is likely to cause condensation on cold interior surfaces and in building cavities when outdoor weather is cold.

Symptoms of Moisture Problems
Condensation on windows, walls, and other surfaces may signal high RH and the need to find and reduce moisture sources. During very cold weather or rapid weather changes, condensation may occur. This occasional condensation is not a major concern. However, if window condensation is a persistent problem, reduce moisture sources, add insulation, or consider other remedies that lead to warmer interior surfaces. The colder the outdoor temperature, the more likely condensation will occur. Adding insulation helps eliminate cold areas where water vapor condenses.

Moisture problems arise when the moisture content of building materials reaches a threshold that allows pests like termites, dust mites, rot, and fungus to thrive. Asthma, bronchitis, and other respiratory ailments can be exacerbated by moisture problems because mold, mildew, and dust mites are potent allergens. The level of moisture problem can be determined by the current state of the existing building materials. The following are examples how moisture affects building materials:

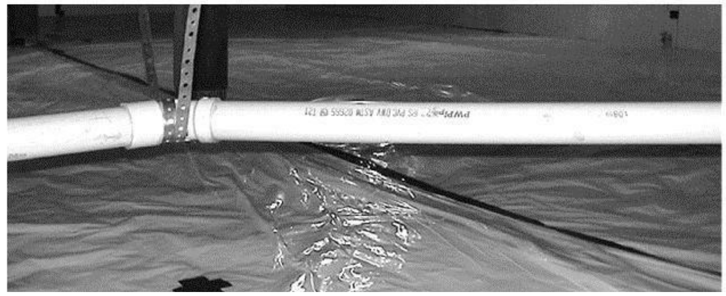
1. Rot and wood decay indicate advanced moisture damage. Unlike surface mold and mildew, wood decay fungi penetrate, soften, and weaken wood.
2. Peeling, blistering, or cracking paint may indicate moisture is moving through a wall, damaging the paint and possibly the building materials underneath.
3. Corrosion, oxidation, and rust on metal are unmistakable signs moisture is at work. Deformed wooden surfaces may appear as damp wood swells and then warps and cracks as it dries.
4. Concrete and masonry efflorescence often indicates excess moisture at the home's foundation. Efflorescence is a white, crystalline deposit left by water that moves through masonry leaving behind minerals from mortar or the soil as it evaporates.

5.4.5 Foundation Moisture Control

Moisture and pollutants entering the home through foundations, basements, and crawl spaces can be a substantial contributor to indoor humidity and affect the indoor air quality, even when no wet areas are apparent. The pollutants and moisture can move easily through the home, driven by stack effect and by wicking of the moisture into permeable wood and concrete.

Ground Moisture Barriers

Air, moisture, and pollutants can move through soil and into crawl spaces and dirt-floor basements. Even soil that seems dry at the surface can release a lot of moisture into the home.



A well-sealed crawl space: The dirt floor in this crawl space is covered with a well-sealed cross-linked polyethylene ground moisture barrier.

Follow these instructions when installing a ground vapor retarder to control the movement of moisture and soil gases:

1. Inspect all plumbing for leaks and repair any leaks found before installing the ground vapor retarder.
2. Cover the ground completely with an airtight barrier, such as 6-mil plastic or cross-laminated polyethylene.
3. Overlap seams a minimum of 12 inches using a “reverse shingle” or “upslope lapping” technique (e.g., overlapping so water leaking through the foundation will not flow in between the layers of poly at the seams).
4. Run the barrier up the foundation wall at least 6 inches or attach it to the mudsill if termites are not a problem in the area. Air seal edges to the foundation.
5. Seal seams and around penetrations with adhesive to create an airtight seal. It may be easier to assemble and seal the seams of the barrier outside of the crawl space. When the sealing compound sets up, the barrier should be a continuous sheet.

Caution: Vapor retarders are typically for use in crawl spaces. Use in basements should be limited to basements with dirt floors and limited access. When the ground vapor retarder is installed in a little-used basement, install walk boards to prevent the customer from slipping. Address any problems, such as plumbing leaks, prior to installing the barrier to prevent water from pooling on top of the barrier.

Open Block Cores

Pollutants and moisture are often found in the bottom of concrete block foundations. When the top of the wall is not sealed or capped, the pollutants and moisture are pulled up into the home due to stack effect and convective looping inside the open cores of the wall. Cap the open cores at the top of the foundation wall using rigid material and air seal around the perimeter of the cap. Treating block cores in this fashion can limit the entrance of moisture and pollutants into the home.

5.5 Lead Paint and Lead-Safe Work

Lead dust can damage the neurological systems of persons who ingest it. Children are more vulnerable than adults because of their rapid brain development and common hand-to-mouth behavior. Lead paint was commonly used in homes built before it was outlawed in 1978.

Technicians working on these older homes should either assume the presence of lead paint or, if they believe no lead paint is present, perform tests to rule out its presence.

Lead-safe work practices are used by weatherization professionals when they suspect or confirm the presence of lead paint. Lead-safe work focuses on rigorous dust-prevention and housekeeping precautions. These practices are required when workers will disturb painted surfaces by cutting, scraping, drilling, or other dust-creating activities. All weatherization field workers must be trained in lead-safe work practices.

Lead Safe Renovator requirements apply in pre-1978 housing when more than 6 square feet of interior painted surface per room or more than 20 square feet of exterior painted surface will be disturbed, or any time windows will be replaced or demolished. See the Wisconsin Weatherization Program Manual for specific policies and guidance regarding Lead Safe Renovator requirements and minimum standards for lead-safe weatherization.

Wall-blowing tent: This tent protects the customer and their belongings from insulation and paint dust.

Weatherization activities that could disturb lead paint and create lead dust include, but are not limited to, the following:

1. Removing siding for installing insulation.
2. Drilling holes in the interior or exterior of the home for installing insulation.
3. Removing trim or cutting through walls or ceilings.
4. Weather-stripping, repairing, or replacing doors.
5. Glazing, weather-stripping, or replacing windows.

When engaging in the above activities, take the following precautions:

1. Tent off the work area by taping a continuous sheet of plastic from floor to ceiling.
2. To protect installers from breathing dust, use appropriate personal protective equipment, such as fit-tested respirators, and coveralls, etc.
3. Confine the work area within the home to the smallest possible floor area. Seal this area off carefully with floor-to-ceiling barriers made of disposable plastic sheeting, sealed at floor and ceiling with zip poles or tape.
4. Cover furniture and carpet in the work area with disposable plastic sheeting.

Lead-safe drilling: Using a shrouded drill with a HEPA vacuum removes dust where it is generated.

5. Spray water on the painted surfaces to keep dust out of the air when drilling, cutting, or scraping painted surfaces.
6. Use a dust-containment system with a HEPA vacuum when drilling holes indoors.
7. Clean up as work is performed. Vacuum affected areas with a HEPA vacuum and wet-mop these surfaces daily. Do not use the customer's cleaning tools. Do not leave the customer with lead dust to clean up.
8. Avoid taking lead dust home by not contaminating clothing, shoes, or tools. Wear boot covers while in the work area and remove them to avoid tracking debris from the work area to other parts of the house. Wear disposable coveralls, or vacuum cloth coveralls with a HEPA vacuum before leaving the work area.
9. Wash hands and face thoroughly before eating, drinking, or quitting for the day.
10. Keep customer and pets away from the work area.

5.6 Asbestos

Airborne asbestos fibers can be dangerous, even when they are not visible to the naked eye. Exposure to asbestos can lead to a host of health problems including, but not limited to:

1. Lung cancer.
2. Mesothelioma, a rare form of cancer found in the thin lining of the lung, chest, abdomen, and heart.
3. Asbestosis, a serious progressive, long-term, non-cancer disease of the lungs.

Disease symptoms may take many years, or decades, to develop after exposure to asbestos. Being a smoker greatly increases the odds exposure to asbestos will lead to disease.

According to Wisconsin Department of Health Services, workers may assume asbestos is not present in wood, metal, glass, and fiberglass. All other building materials should be presumed to contain asbestos, unless proven otherwise through bulk sampling by a certified Asbestos Inspector and analysis by an accredited laboratory. Asbestos that may be mixed in with Vermiculite insulation is the one exception — currently, there is no EPA-approved testing method to demonstrate the presence or absence of asbestos mixed in with vermiculite insulation. Consequently, weatherization workers must always presume that asbestos is mixed in with all vermiculite insulation.

See the Wisconsin Weatherization Program Manual for comprehensive asbestos policies.

5.7 Electrical Safety

Follow these steps for electrical safety in existing homes:

Knob-and-tube wiring: Prior to insulating around knob-and-tube wiring, barriers must be installed to keep insulation at least 3 inches from the wires.

1. Confirm attics contain no exposed wiring. All splices and connections should be in junction boxes.
2. Install covers on open junction boxes in the attic or elsewhere in the building if an imminent hazard exists for the workers or customer.
3. Mark all junction boxes in the attic that will be concealed by insulation using flags.
4. Do not insulate wall cavities containing live knob-and-tube wiring. Eliminate live knob-and-tube wiring whenever feasible.
5. If knob-and-tube is not being re-wired as part of the job, isolate live wiring in attics by building a barricade around it. There are several materials that work well as barricades: R-30 unfaced fiberglass batts, concrete-form tube, or other industry-accepted materials. Keep the barricade materials at least 3 inches away from the live knob-and-tube wiring.
6. Inspect wiring, fuses, and circuit breakers to confirm wiring is not overloaded. Install S-type fuses where appropriate to prevent circuit overloading. Maximum fuse or breaker amperage for 14-gauge wire is 15 amps and 20 amps for 12-gauge wire.

S-type fuse: An S-type fuse prohibits the customer from oversizing the fuse and overloading an electrical circuit.

5.8 Combustion Appliance and Fuel Distribution Safety

Determining the safety of combustion appliances and fuel distribution within a dwelling is critical to ensuring occupant safety. Verifying the venting systems for combustion safety are working safely and effectively removing all byproducts of combustion is an essential part of confirming indoor air quality. Fossil fuels can affect indoor air quality and can be an explosive hazard when fuel leaks are present within the dwelling.

Combustible gas detector: These electronic combustible gas detectors are a convenient way to find gas leaks.

5.8.1 Gas Piping Inspection

Natural gas and LPG piping system leaks can be located with an electronic combustible gas detector (CGD), often called a gas sniffer. CGD equipment must:

1. Be classified to UL 913 Intrinsically Safe or equivalent,
2. Have a variable tick rate or changing tone for varying concentration levels,
3. Have a digital display of percentage of Lower Explosive Limit (LEL) and/or provide an alarm when above 10% of LEL, and
4. Have ability to zero ambient conditions.

Safe Environment – Fuel Distribution

Upon entry of a building, the auditor and inspector shall sample ambient air with the CGD in at least one location per floor of occupied space. If any location exceeds 10% of the LEL, the auditor or inspector shall inform the occupants and advise evacuation of the building. Emergency services and/or the gas provider shall be notified from outside of the building.

Upon completion of weatherization on a dwelling, the inspector shall sample ambient air with a CGD in at least one location per floor of occupied space to confirm no gas leaks are present in the home.

Gas Leak Detection

A CGD will find all significant gas leaks, if used properly. Natural gas and LPG fuel distribution or piping systems may leak at joints and valves. Natural gas is lighter than air and rises from a leak, while LPG is heavier than air and sinks from a leak.

Test for gas leaks by following these steps:

1. Using a CGD, inspect all piping from the meter or tank to all connected appliances checking the entire length of piping, the circumference of all valves and joints at a rate of 1 inch per second. Connections to all gas appliances shall also be inspected. Position the CGD above piping and joints for natural gas and below for LPG gas.
2. If a leak is identified with the CGD, verify the leak with a non-corrosive leak detective solution designed for finding gas leaks. Mark all confirmed leaks with flagging tape or equivalent product.
3. Replace kinked or corroded flexible gas connectors.
4. Repair all verified gas leaks. No gas leaks are allowed in the building or on the customer side of the meter or propane tank at the completion of weatherization work.
5. When CSST is already present in the building and not correctly bonded, bond the gas piping system to the electrical ground in accordance with NEC 250.94 and 250.104 when completing work on the gas piping.

5.8.2 Ambient CO Monitoring

Auditors and inspectors perform ambient CO monitoring during assessments and combustion safety testing to ensure a safe environment.

Ambient CO Monitoring during Building Assessments/Inspections

At all times while assessing the building, auditors and inspectors shall operate a designated ambient CO monitor. CO measurements shall be conducted in all occupied spaces within the building.

If the ambient CO level is **70 ppm or higher**, the auditor or inspector will stop the audit or inspection, notify the occupants of the need to immediately evacuate the building, and leave the building and call emergency services from outside.

If the ambient CO level is in the **range of 36 to 69 ppm**, turn off any appliances that may be producing CO, open the windows and/or doors, and inform the occupants elevated levels of CO were detected.

If the ambient CO level is in the **range of 9 to 35 ppm**, turn off any appliances that may be producing CO, inform the occupants elevated levels of CO were detected, and recommend windows and/or doors be opened.

Ambient CO Monitoring during Appliance Testing

Additionally, ambient CO shall be monitored while performing combustion safety testing as defined in *Chapter 5 – Section 5.8.3* or while testing a gas range and/or oven. If ambient CO levels exceed 35 ppm, immediately cease testing, turn off the appliance, and open windows and/or doors to dilute levels of CO in ambient air.

5.8.3 Combustion Appliance Safety Inspection

Conduct CO measurements and spillage assessments on natural draft appliances equipped with a barometric damper and all Category I gas appliances connected to a natural draft venting system. CO measurements shall be conducted on gas ovens and direct vent combustion equipment. Depressurization testing is required in all CAZs with permanent natural drafting fuel burning appliances (see *Chapter 5 – Section 5.10*). When appliances are replaced during the weatherization process, testing requirements may change.

Building Setup

1. In preparation for testing, place all combustion equipment inside the Combustion Appliance Zone (CAZ) in standby mode. Turn off any air handlers. Combustion air openings to the outdoors shall be open.
2. Ensure all wood fires are fully extinguished with no hot coals. Shut all fireplace dampers and/or doors.
3. Close all exterior building doors and windows. Close all CAZ doors.
4. Close all interior doors to rooms with NO return air.
5. Leave doors open to rooms with an exhaust fan.
6. Turn off any mechanical ventilation and exhaust equipment.

Greatest Depressurization Achievable

Follow the steps below to place the CAZ under the greatest depressurization achievable (GDA). Subsequent spillage assessments and CO measurements shall be conducted while the CAZ is under the GDA. Run a hose to the outdoors from the reference tap of a digital gauge to measure pressure. If the gauge is not in the CAZ, run hose from the input tap to the CAZ.

1. **Baseline depressurization:** Measure and record the baseline pressure differential or Delta P (Δ P) between the CAZ and the outdoors.

   If the baseline measurement seems unreasonable, ensure the pressure hose to the outdoors is not constricted.

2. **Turn on exhaust appliances:** Turn on all exhaust appliances, including any Category III or IV indirect vented gas appliances while excluding whole house ventilation, in the building and record the Δ P between the CAZ and the outdoors.

   A pressure differential more negative than the reading from Step 1 usually indicates the exhaust fans have depressurized the CAZ. Pressure effects caused by exhaust appliances will be assessed and corrected when the impact could be harmful to the customer or building.

3. **Turn on the air handler:** Turn on the furnace and/or central air conditioning air handler and record the Δ P between the CAZ and the outdoors. Below are options for turning on an air handler.

   a. At the thermostat, use the Fan On option to start the air handler.

   b. Start the forced air furnace and let it operate until the air handler starts.

   c. Use a jumper from the R and G thermostat leads to create the Fan On circuit.

      i. When the forced air furnace is commonly vented with another appliance, this step may be skipped if a fan only option is not available and tester is not comfortable with R to G jumper.

   If the Δ P has become more negative than in Step 2, it usually means leaky return ducts in the CAZ or supply leaks in an attic have depressurized the CAZ. In contrast, a more positive Δ P usually means leaking supply ducts in the CAZ or return leaks in an attic have pressurized the CAZ. If the CAZ is pressurized by the air handler, turn it off before continuing to Step 4.

4. **Open the door to the CAZ:** Open the door to the CAZ and record the Δ P between the CAZ and the outdoors.

   If the pressure difference is more negative than in Step 3, leave the CAZ door open. It may mean the exhaust fans are depressurizing the CAZ. If the pressure difference is more positive, close the CAZ door.

Spillage Assessment and CO Measurement

Identify the conditions under which the greatest depressurization was achieved and set up the building to match. For example, exhaust fans on, air handler on and CAZ door open. NOTE: If you started the air handler by operating the furnace, you may not be able to test a water heater connected to a shared natural venting system with the air handler running without the furnace operating.

For domestic water heaters or appliances connected to a **warm venting system**, spillage shall be assessed at 2 minutes of main burner operation. CO measurement of undiluted flue gas shall be taken at 5 minutes of main burner operation. Compare CO measurements to acceptable CO limits (see *Table 5-2*) and take corrective actions as needed.

NOTE: If you ran the furnace in Step 3 to start the air handler and if connected to a natural drafting venting system, it will be warm.

For appliances connected to a **cold venting system**, spillage and CO measurements shall be assessed at 5 minutes of main burner operation. Compare CO measurements to acceptable CO limits (see *Table 5-2*) and take corrective actions as needed.

For combustion appliances **sharing a chimney and/or venting system**, testing is completed in order from lowest BTU/hr input rating to highest BTU/hr input rating. Complete testing of the smallest BTU/hr appliance following the procedure for a cold or warm venting system as appropriate to the system's condition. After completion of spillage and CO measurements, place the next largest BTU/hr combustion appliance in operation while the first appliance is still firing. After 2 minutes of operation, test for spillage on the first appliance and then immediately after check spillage for the second appliance. Measure CO of the second appliance after 5 minutes of operation. Compare the CO measurements to acceptable CO limits (see *Table 5-2*) and take corrective actions as needed.

For **direct and power vent appliances**, CO Measurement of undiluted flue gas shall be taken at 5 minutes of main burner operation. Compare the CO measurements to acceptable CO limits (see *Table 5-2*) and take corrective actions as needed. Test for CO prior to the addition of dilution air. If unable to test prior to the dilution air, then test after air dilution or test at the appliance exhaust termination.

Spillage Corrective Actions

When spillage is identified, corrective actions are recommended based on conditions causing the GDA. To verify spillage is not caused by a non-code compliant venting system, check for spillage under baseline conditions.

- If spillage occurs under baseline/natural conditions, correct the venting system to make it code compliant.
- If GDA is caused by the air handler operation, evaluate the forced air distribution system and complete duct sealing as needed. If GDA occurs with CAZ door closed, evaluate the forced air distribution system, and increase the amount of return air, if possible.
- If GDA is caused by high exhaust flow rates, consider reducing exhaust flow rates or installing make-up air. If neither option is acceptable, consider replacement of the appliance with spillage.

CO Corrective Actions

If measured CO exceeds the thresholds outlined in the acceptable CO limits (see *Table 5-2*), service the appliance to reduce production of CO or consider replacement of the appliance.

Table 5-2 Acceptable CO Limits

CO Thresholds for Fuel Fired Combustion Appliances	
Appliance	**Threshold Limit**
Central Furnace (all categories)	400 ppm air free
Boiler	400 ppm air free
Floor Furnace	400 ppm air free
Gravity Furnace	400 ppm air free
Wall Furnace (BIV)	200 ppm air free
Wall Furnace (Direct Vent)	400 ppm air free
Room Heater*	200 ppm air free
Water Heater	200 ppm air free
Clothes Dryer	400 ppm air free
Gas Log Fireplace	25 ppm as measured in vent
Gas Log (in wood fireplace)	400 ppm air free in firebox
Gas Oven/Broiler	225 ppm as measured

**Unvented heaters may not remain in completed weatherized buildings.*

Range-Top Burners

Inspect range-top burners prior to testing ovens for carbon monoxide levels. Dirty or misaligned range-top burners may cause generation of excessive CO. Damaged burners or stove grates, or foil burner liners that interfere with the flame pattern, may cause the burner to create a yellow or orange flame. In this condition, the burner is likely generating high volumes of carbon monoxide. If any of these conditions are observed, advise the occupants the range should be cleaned or repaired by a qualified professional to reduce the generation of CO.

Testing Gas Ovens

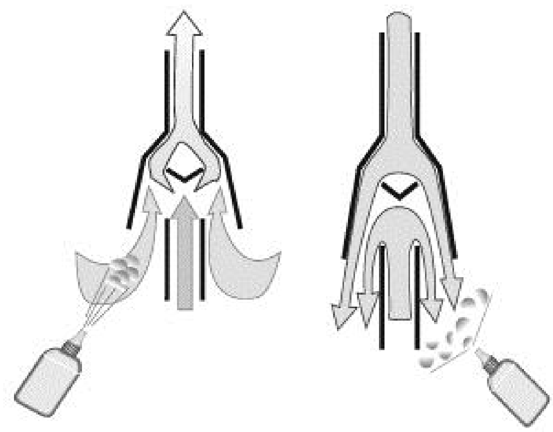
While the oven is turned off, complete a visual inspection.

1. Check for air blockage at the bottom of the oven and/or drawer and remove any obstructions.
2. Remove any items stored in the oven and any foil coverings that may be obstruction air venting.
3. Inspect the oven for cleanliness. Testing can be affected by a dirty oven. Advise occupants to clean oven to reduce generation of CO.

Turn the oven on to a temperature of 500°F. Do NOT turn up to the highest setting, broil setting or self-cleaning setting. After 5 minutes of operation, insert the testing probe into the throat of the oven exhaust vent and measure undiluted CO. Record stabilized “as measured” level of CO. Advise occupant/owner to have oven serviced by a qualified professional if measurement is higher than 225 ppm as measured.

5.9 Measuring Natural Draft

Measuring draft for gas appliances is not required but can be a useful test to confirm spillage or to assess the strength of the venting system. Draft is measured in inches of water column (IWC) or pascals (Pa). Measuring over fire draft is required for oil appliances and should not exceed the manufacturer’s specifications (usually .02 IWC or 5 Pa). Excessive overfire draft can be reduced by adjusting the barometric damper.



Spillage: A smoke tester helps determine if spillage is occurring during appliance operation.

Natural draft is produced by the difference in the weight of a column of flue gases within a chimney or vent and a corresponding column of air of equal dimension outside the chimney or vent. A negative pressure in the chimney or vent with respect to indoors is created by natural draft. The strength of this draft (weight difference) is determined by the venting height, its cross-sectional area, and the temperature difference between the column of flue gases and the column of air. Measured natural draft in a venting system should always be negative with respect to indoors. A positive reading indicates the flue gases are spilling into the **combustion appliance zone (CAZ)**. A CAZ is any location in a building where combustion appliances are located, most often the basement in Wisconsin.

Venting systems transport combustion gases using the flame’s heat and the gases’ buoyancy. Natural draft and fan-assisted gas appliances are designed to operate at a natural draft of around negative 0.02 IWC, or - 5 pascals. Tall venting systems located indoors typically produce stronger drafts, and short or outdoor venting systems produce weaker drafts. Wind and house pressures can have a big impact on natural draft in venting systems. Depressurization can cause spillage of combustion gases into the CAZ.

Natural draft appliances connected to chimneys or vents require a draft diverter to dilute the flue gases and limit the chimney temperature, keep the draft from getting too strong, and keep wind gusts from interfering with the appliance’s burner.

Fan-assisted appliances employ a small fan near the exhaust of their heat exchanger. This fan draws the products of combustion through the heat exchanger, but it has little or no effect on the draft up the chimneys. A poorly functioning natural draft chimney may allow combustion gases to leak into the CAZ.

Higher efficiency appliances, including sealed combustion heating systems and power-vent water heaters, employ mechanical draft. This mechanical draft is produced by a fan. When the fan is located to push the flue gases through the venting system, the draft is forced. When the fan is located to pull the flue gases through the venting system, the draft is induced. A positive pressure in the venting system with respect to indoors is created by mechanical draft after the fan. The venting system must be airtight after the fan otherwise the positive pressure inside the venting system will force combustion gases into the CAZ. The mechanical draft created is strong enough to resist the influence of most indoor and outdoor pressures.

Before testing, inspect the combustion venting system for damage, leaks, disconnections, inadequate slope, and other safety hazards.

5.10 Depressurization Guidance

Subtract the baseline reading from the largest negative reading (or the smallest positive) if baseline was manually measured and recorded, to get the greatest depressurization achievable (GDA). If the automatic baseline feature was used, record the largest negative reading (or the smallest positive). Compare the GDA value to those in Table 5.5. If the GDA is greater than the listed maximum value, the possibility of spillage occurring is more likely. For wood fired appliances or fireplaces, consider make-up or dedicated combustion air when GDA exceeds -5 Pa.

Table 5-5: Depressurization Guidelines for Combustion Appliance Zones

Appliances and Venting Systems	Maximum Depressurization (pascals)
Orphaned Natural Draft Water Heater (oversized venting system). *Note: chimney lined with clay or other liner but still oversized*	-2
Natural Draft Water Heater and Natural Draft Heating System with common venting	-3
Stand Alone Natural Draft Water Heater (properly sized venting system)	-5
Natural Draft Heating System or Stove (including wood burning systems)	-5
Natural Draft Water Heater and Fan Assisted Heating System (fan inside furnace cabinet) with common venting	-5
Natural Draft Water Heater and Induced Draft Heating System (fan at point of exit at wall) with common venting	-5
Induced Draft Heating System (fan at point of exit at wall)	-15
Power Vented Water Heater and Sealed-Combustion Heating System	-25
The Maximum Depressurization Guideline (MDG) is the most restrictive MDG in the Combustion Appliance Zone (CAZ).	

5.10.1 Make-Up Air Systems

Make-up air may be an option when the combustion appliance zone is excessively pressurized or depressurized and the appliance does not pass worst-case draft. Use guidelines listed in *Table 5-5 Depressurization Guidelines* to determine acceptable pressures. Add make-up air equal to 40 percent of the total exhaust ventilation. Multiply the total exhaust CFM (both continuous and intermittent) by 40 percent (0.40) to determine the amount of make-up air required (CFMs).

Make-up air systems provide supply air by way of fans and/or ductwork that introduce outdoor air into the home. These systems are sometimes electrically interlocked with exhaust fans elsewhere in the home so both fans run at the same time. This protects against the depressurization caused by large exhaust-only fans such as oversize range hoods. Balancing of the two air flows can be performed by balancing dampers in the fresh air duct. These systems, if properly balanced, can create house pressures closer to neutral than exhaust-only or supply-only systems. Follow the manufacturer's requirements for mixed air temperature and the location of the fresh air inlet if connecting the make-up air duct to the return side of a forced air furnace.

When make-up air is installed, label the intake fitting “ventilation air intake” and educate the customer to keep yard debris and other contaminants clear of the intake.

5.11 Water Heater Replacement

Occasionally, water heaters must be replaced for health and safety reasons. For information on replacement installation procedures, refer to *Water Heater Replacement in Chapter 4 – Section 4.1*. These reasons may include, but are not limited to:

1. Water heater is backdrafting/spilling. Refer to *Improving Inadequate Draft in Chapter 3 – Section 3.14.1* for guidance on how to remedy these problems.
2. The shell of the storage tank actively leaks and cannot be repaired.
3. Severe flame rollout that cannot be repaired.
4. Carbon monoxide measurement above 200 ppm air-free that cannot be repaired.

5.12 Mechanical Ventilation

Ventilation is an important health and safety consideration in homes weatherized in Wisconsin. Many homes have blower door-measured airtightness and building characteristics that necessitate mechanical ventilation as a means of keeping indoor air quality at a safe level.

The customer may refuse the installation of ventilation in their home. Any customer refusing the installation of ventilation must sign the *Refusal of Ventilation: Release of Liability, Indemnification and Waiver of Claims*, available via the link at the beginning of *Chapter 5*. Refusal of ventilation does not constitute refusal of a major measure but will not be an eligible DOE job. An original copy of the waiver must be given to the customer and a copy retained in the customer’s file.

5.12.1 Choosing Ventilation Systems

Ventilation systems must be matched to the home. A home may require only simple exhaust fans in bathrooms and/or the kitchen to provide adequate ventilation. Very tight homes may require a balanced centrally ducted ventilation system.

When ducted ventilation systems are installed in homes with forced-air heating or cooling systems, the ductwork can be shared in a simplified or ducted exhaust installation. Though these hybrid approaches can save some of the initial cost, these systems are more complicated, require an interlock with the furnace fan, and are prone to pressure imbalances. Install fully ducted systems whenever possible.

In cold climates, heat-recovery ventilators (HRVs) or energy-recovery ventilators (ERVs) can offset some of the heat loss from exhausted air. The heat-recovery savings will be greatest when winter temperatures are the lowest.

5.12.2 Sizing Ventilation Systems

Whole-building ventilation systems are sized according to the size of the home and the number of occupants as described by the ASHRAE 62.2 standard. Use the Diagnostic Workbook to determine if whole-building ventilation is required. Note: Existing ventilation may be modified to provide either continuous or intermittent ventilation at the required amount, based on the integrity of the existing installation.

5.12.3 Local Exhaust Fans

The ASHRAE 62.2 standard for acceptable indoor air quality establishes an on-demand or an optional continuous flow rate for local exhaust in bathrooms and kitchens. An alternate compliance path that increases the flow rate of whole-building ventilation to offset the lack of local exhaust is available for existing homes.

Follow these instructions when installing local exhaust fans to remove bulk pollutants and moisture:

1. Locate exhaust fans as close to the source(s) of pollutants/moisture as possible. For example, install bath fans in the shower or as close as practical, and install kitchen fans near the range.
2. Install exhaust fans as close as possible to the heated space, which usually means against the ceiling surface.
3. Consider the positioning of the new fan's exhaust port. Position ceiling fans so the exhaust port runs parallel with the ceiling joists and points toward the existing exhaust termination. If no existing termination is present, best practice is usually to point the fan's exhaust port toward the center of the attic. This makes it easier to attach exhaust ducting.
4. Avoid installing fans in vaulted ceilings, walls, or slopes if possible. These installations displace insulation and make it difficult to avoid cold spots, which foster condensation. In addition, these installations make it difficult to duct the fan to the outdoors.

5.12.4 Whole-Building Exhaust-Only Ventilation

The ASHRAE 62.2 standard for acceptable indoor air quality establishes a rate for whole-building ventilation based on floor area and the number of occupants. When natural ventilation does not fulfill the entire established rate for whole-building ventilation, mechanical ventilation is installed. In Wisconsin, the most common approach is exhaust-only ventilation. Local exhaust requirements may also be met by increasing the flow rate of installed whole-building ventilation.

Surface-mounted exhaust fan: Exhaust fans aid air quality by drawing fresh air into the building as they remove indoor pollutants.

Follow these instructions for the installation of whole-building exhaust ventilation:

1. Install fans in bathrooms or kitchen when practical to reduce overall flow rate when following alternate compliance for local exhaust requirements.
2. In-line exhaust fans may be installed in a remote location such as the attic or basement. Ducting can be installed to one or two intake locations and then terminated to the outdoors. One option is to use the existing ceiling exhaust as an intake location after removing the fan assembly from the housing. This option avoids cutting new holes in ceilings.
3. Install exhaust fans in basements as an alternative to avoid disturbing existing insulation in attics or to avoid cutting/drilling through lead- and/or asbestos-containing surfaces. CAUTION: The rate of flow may be higher as compared to a fan installed in a bathroom that will also meet local exhaust requirements. Exhaust fans in basements will cause higher depressurization levels that may cause spillage in natural drafting venting systems.
4. Install fans with built-in controls or install a separate control to allow for the adjusting of the flow rate and frequency-of-operation as needed. Label all controls.
5. Install a service or shut-off switch if not an integral part of the fan control. Label all controls.
6. Measure the flow rate of the installed exhaust ventilation and record on Diagnostic Workbook. Record the highest flow rate in the exhaust fan section. Record the continuous or intermittent rate in the ventilation section.
7. Adjust the controls to provide the required flow rate at a continuous rate. Adjust controls for frequency-of-operation when operating intermittently. Intermittent operation should occur at least once in every three-hour time period.
8. Calculate intermittent operation using this formula: required flow / rate measured flow rate x 60. The result is the number of minutes per hour the ventilation should operate. The Diagnostic Workbook will assist installers in setting operational controls.

5.12.5 Exhaust Fan Ducting

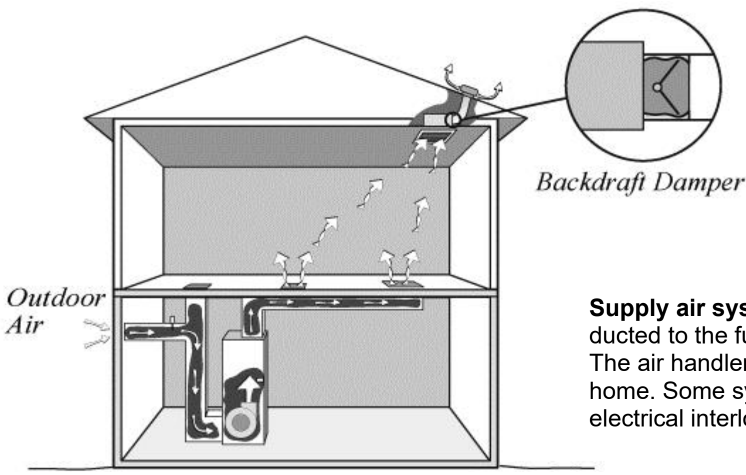
Discharge exhaust fan ducting to the outdoors and not to an attic, crawl space, or garage, where moisture and pollutants can accumulate. Duct exhaust fans to the outdoors as follows:

1. Use flexible or rigid ducting material.
2. Ensure a backdraft damper is present. The damper may be part of the termination hood, it may be integrated into the fan unit, or it may be installed separately in the exhaust duct.
3. Where practical, begin the ducting run by connecting a one- to two-foot section of straight rigid duct to the fan's exhaust port, to improve air flow.
4. Avoid installing elbows at 90-degree angles — this can reduce air flow. Instead, install elbows at as gradual and smooth of an angle as is reasonable.
5. Make duct runs as short as is practical. Avoid long duct runs, especially where they are above the insulation or running horizontally.
6. Attach the ducting material to the fan's exhaust port and to the termination hood.
7. Seal all joints in the exhaust-ducting run including at the fan and termination.
8. Insulate the ducting to a minimum of R-8 in unheated spaces. Ensure the insulation is secure and provides continuous coverage.
9. In multi-family housing, for continuous ventilation, multiple exhaust fans may be combined into a "collector box" and exhausted with an appropriately sized termination hood. In these cases, ensure there is a backdraft damper integrated into every fan unit.
10. Use a termination fitting with an integrated collar. The termination shall have a screen material installed so it does not inhibit damper operation or restrict air flow.
11. Install termination hoods to the outdoors and not to a buffer zone, such as an attic, crawl space, or garage, where moisture and pollutants can collect.
12. A termination shall be installed a minimum of 3 feet away from any property line, a minimum of 3 feet away from operable openings to houses, a minimum of 10 feet away from mechanical intakes, or as required by authority having jurisdiction.
13. Install the top half of roof caps underneath the shingles, in order to prevent rainwater from leaking into the attic. Use galvanized or stainless-steel fasteners and use roofing cement to seal any leakage points.
14. Galvanized steel, stainless steel, or copper shall be used for termination fitting for kitchen exhaust fans.

5.12.6 Supply Ventilation Systems

Supply ventilation systems introduce fresh air into the home and do not include heat recovery. They are usually installed in conjunction with forced-air heating or cooling systems. They incur an energy penalty as unconditioned air is brought into the home. It is critical with this, and any other installation utilizing the forced-air system, to follow the manufacturer's requirements for mixed air temperature and the location of the fresh air connection. Introducing very cold outdoor air directly into a forced-air furnace creates a risk of cracking the heat exchanger and will void the heating system warranty. The temperature of the air into the return side of the furnace cabinet should never be below 60°F for systems with continuous outdoor air supply or 55°F with an intermittent air system. Also, since this modification could result in cooler supply register air temperatures, the customer must understand and agree to this installation. Simple supply systems are difficult to balance effectively, especially in well-sealed homes. Central balanced ventilation systems are often a better choice considering overall efficiency and the need to balance house pressures.

The most common type of supply-only ventilation includes an outdoor air duct connected to the main return of a central forced-air heating or cooling system. The HVAC system's fan draws outdoor air into the plenum, delivering ventilation air to the home along with heated or cooled air. No ventilation air is supplied unless heating or cooling is needed.



Supply air system: Fresh air is ducted to the furnace return plenum. The air handler draws air into the home. Some systems include an electrical interlock with exhaust fans.

The fresh air duct should have a balancing damper installed so the air flow can be adjusted during the initial installation. A motorized damper is sometimes installed to close the outdoor air duct when ventilation air is not needed.

Supply ventilation systems pressurize the home, forcing indoor air out through openings in the shell. This may keep outdoor pollutants, such as carbon monoxide from vehicles and lawn chemicals, out of the home as long as the fresh air intake draws air from a clean location.

The positive house pressure created by supply ventilation systems can force indoor moisture into the walls. This can promote condensation in building cavities during cold weather. Moderate levels of pressurization are not usually a concern, though, if indoor RH is kept at or below 35 percent.

Supply systems introducing air to the HVAC system can be configured to provide fresh air when neither heating nor cooling systems are operating. In this mode, the HVAC fan can be set up to circulate ventilation air only. This method is most efficient when a variable-speed HVAC fan allows the slower air flow required for ventilation-only operation. Single-speed HVAC fans move too much air and consume too much electrical power for efficient continuous operation.

5.12.7 Balanced Ventilation Systems

Balanced ventilation systems provide measured fresh air via planned pathways. Of all the ventilation schemes, these systems can do the best job of controlling pollutants in the home when properly installed. Balanced systems move equal amounts of air into and out of the home. Most balanced systems incorporate heat-recovery ventilators that reclaim some of the heat and/or moisture from the exhaust air stream. Simple mixing boxes are occasionally used to temper incoming air by mixing it with exhaust air, but their cost approaches that of heat-recovery ventilators, and they incur an energy penalty as conditioned air is lost to the outdoors.

When operating properly, balanced systems reduce many of the safety problems and moisture-induced building damage possible with unbalanced ventilation. Balanced systems are not trouble-free, however. Proper design, installation, and maintenance are required for effective operation.

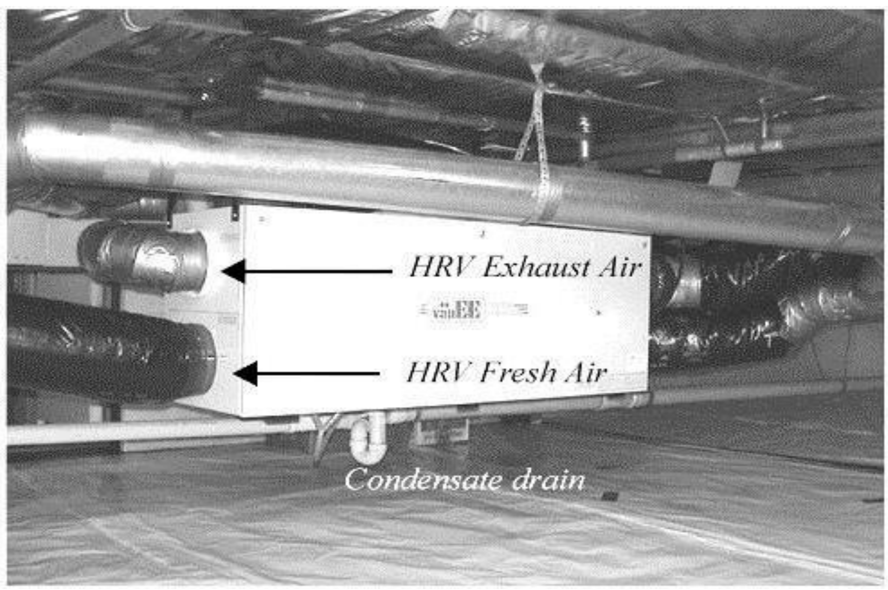
These complicated systems can improve the safety and comfort of the home, but they require regular customer maintenance and periodic service (preferably by a knowledgeable professional) to ensure they operate properly. Testing and commissioning are vital during both the initial installation and periodic service calls.

Variation 1: Fully Ducted and Balanced Systems

The most effective central ventilation systems include dedicated ductwork for both supply and exhaust air. All the system ducting leads to a central ventilator, which includes an HRV core to reclaim heat.

Fully ducted systems are installed independently of other forced-air ducting. This gives the designer a high level of control over air flow and house pressure. They are most easily installed in new construction and are more difficult to install during weatherization.

High-quality ductwork is a critical component of successful ventilation systems. Ducts should be sized large enough to minimize static pressure and reduce noise, and hard metal ducting should be used wherever possible. All seams and joints should be sealed using mastic or metallic tapes or other UL181 approved material. Exhaust grilles should be installed near the sources of contaminants in bathrooms, kitchens, or other areas where other pollutant-producing activities take place.

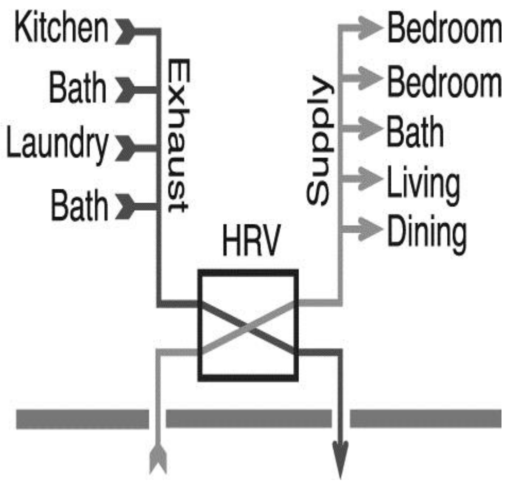


Fully ducted heat-recovery ventilator: Matched exhaust and supply fans provide balanced air flow. Dedicated exhaust ducting collects pollutants from bathrooms and kitchen. Supply ducting carries fresh air to bedrooms and central living areas. A heat-recovery core reduces energy loss from exhausted air.

Variation 2: Ducted-Exhaust Balanced Systems

Ducted-exhaust systems are connected to central forced-air systems. Dedicated ducting collects pollutants from bathrooms and kitchens. The exhaust air passes through a central HRV core before being exhausted to the outdoors. Fresh air is brought in through the HRV core, collects the heat extracted from the exhausted air, and is introduced to the forced-air system at either the supply or return plenum. Always follow the manufacturer’s instructions for mixed air temperature, the location of the fresh air insert, and minimum return air temperature.

The air flow should be balanced in ducted-exhaust systems so house pressures remain close to neutral. In practice, this is harder to achieve than in fully ducted systems because of the influence of the forced-air blower. With typical air flows of 50-200 CFM, central ventilators are easily overwhelmed by the 500-1500 CFM air flows of forced-air systems. A high level of care is needed during design, installation, and commissioning of ducted-exhaust ventilation systems to achieve proper air flows and to achieve reliably balanced house pressures.



Fully ducted central ventilator: Fully ducted systems do the best job of collecting pollutants. Installed independently of heating and cooling systems, fully ducted systems work well in homes with hydronic or electric baseboard heat where no ducting is installed.

Variation 3: Simplified Balanced Systems

Simplified, or volume ventilation, systems are connected to central forced-air heating or cooling systems. This is the least-favored ducting option.

Simplified systems draw exhaust air from the forced-air return air plenum. This air passes through the central ventilator that includes an HRV. Most of the exhaust airstream's heat is transferred to supply airstream, and fresh air is re-introduced to the forced-air return ducting. Always follow the manufacturer's recommendation for interlocking the air handler with the fresh air inlet. This system requires regular, effective customer maintenance, as system failure will result if maintenance requirements are not followed.

Polyethylene HRV core: This flat-plate counter flow heat exchanger slides out for cleaning.

5.12.8 Heat-Recovery Ventilators

Heat-recovery ventilators (HRVs) are often installed in conjunction with balanced whole-house ventilation systems. The HRV core is usually a flat-plate aluminum or polyethylene air-to-air heat exchanger in which the supply and exhaust airstreams pass one another and exchange heat through the flat plates.

5.12.9 Heat-Recovery Ventilator (HRV) and Energy-Recovery Ventilator (ERV) Installation

Follow the specifications below when installing a balanced ventilation system:

1. Install the system following the manufacturer specifications.
2. Install a backdraft damper between the heat-recovery ventilator (HRV) or energy-recovery ventilator (ERV) and the exterior.
3. Insulate ducts installed outside of the thermal envelope to a minimum of R-8.
4. Seal the gap between registers or grilles and interior surface.
5. When connected to the heating system, exhaust air shall not draw directly from the heating system. Supply ducts should be installed as close to the HVAC system's fan as possible.
6. Educate the customer about how and when to change filter and clean the drain pan, according to manufacturer specifications.

5.12.10 Ventilation Control Strategies

Controls provide an opportunity for fine-tuning ventilation systems. Controls let the installer and customer choose when the system runs and how much air it moves.

Controls also provide an opportunity to adjust the system performance over time. The customer should be advised a periodic review of the control scheme should be performed, perhaps during service visits, to ensure the system is providing sufficient fresh air for customer and acceptable moisture control for the building.

Locate the controls in a representative location on a main floor interior wall, and about 48 to 60 inches above the floor. Do not install them on an exterior wall, in a drafty location, or in direct sunlight.

Manual Control

Simple on/off manual controls allow the customer to ventilate as needed. These are often used for exhaust fans in bathrooms and kitchens. Their effectiveness relies on a customer's perception of air quality.

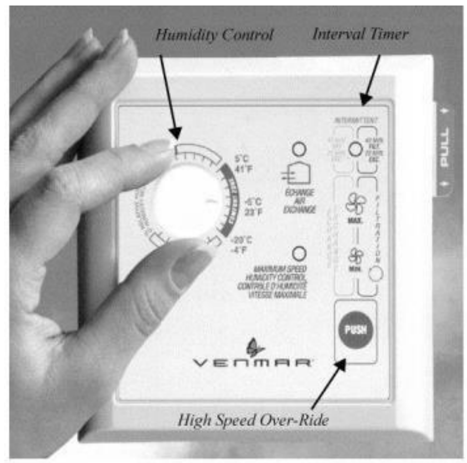
Manual controls sometimes include countdown or time-delay timers activated by customer and run for a specific period of time. In non-owner-occupied homes or other situations where a customer understands and cooperation is unlikely, fan-delay timers can be run in conjunction with bathroom lights to give a set period of ventilation whenever the bathroom lights are used.

Humidity Control

De-humidistats operate equipment based upon indoor humidity levels. They are used with either simple exhaust fans or central ventilation equipment. De-humidistats can be set for a range of humidity levels and have the advantage of automatic operation that does not require much customer management. They should be set to keep indoor humidity low enough to prevent indoor condensation in the winter. This will vary from 30–50% RH, depending upon the outdoor temperature, effectiveness of windows and insulation, and other factors.

Combination Controls

Central ventilation systems are often operated by a combination of manual and automatic controls. The most common strategy utilizes a multi-speed fan that runs on low or medium speed to provide continuous ventilation. Override switches in the kitchen and bathrooms activate high-speed operation to provide intermittent high-speed operation during polluting activities such as cooking, bathing, or cleaning. The total air flow requirement specified by ventilation standards refers to this high-speed operation.



Central combustion control: The system can be controlled by humidity, time interval, or manually.

Timers allow the low-speed operation to be set for variable intervals such as 20 minutes on/40 minutes off per hour, 30 minutes on/30 minutes off, or whatever total ventilation time is needed. This adjustable interval provides an effective method of matching the ventilation capacity to the customer’s needs.

5.13 Dryer Venting

Clothes dryers produce moisture and combustion gases (if gas-fired). These issues become an indoor air quality hazard in homes if not properly vented to the exterior.

Educate the customer about proper maintenance for the dryer vent and termination. The customer should clean the exterior vent termination frequently. Once or twice each year, the customer should clean the rest of the dryer venting system including the venting run ducting and the connection between the dryer and the ducting.

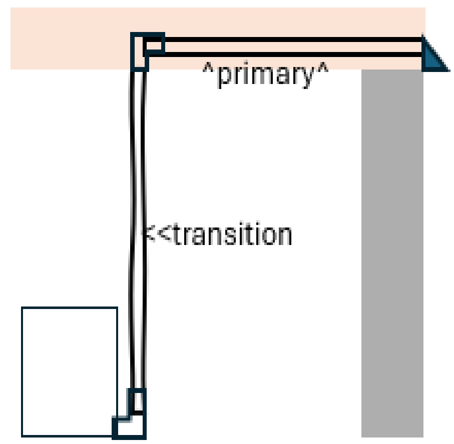
Consider the following when there is existing dryer venting:

1. If the existing flexible transition duct is UL 2158A listed, the duct may be left in place if deemed in good condition with no blockage. Shorten or re-route existing flexible transition duct if needed.
2. If the existing transition duct is vinyl duct or the primary duct is damaged, follow instruction below on how to install new dryer venting.

3. If the entire dryer duct is in good condition, seal all seams and connections with tape or mastic (must be 181B or 181B-M listed material) keeping in mind it may need to be removed for maintenance.
4. If the vent termination is damaged, replace it with a new termination.

Follow these instructions when installing new dryer venting:

1. Vent dryers to the exterior. Do not vent dryers into attached garages, under porches, under decks, or where the moisture will damage building components.
2. Follow the most direct route to the exterior when installing dryer duct, as feasible.
3. Transition duct shall be no more than 8 ft. in length and contain no joints. The flexible transition duct shall be UL 2158A listed.
    a. Transition duct is the section that connects the dryer to the primary duct.
4. Use a hose clamp to fasten the duct to the dryer's exhaust port. Do not use any type of mechanical fastener to make this connection.
5. Primary duct shall be rigid, 30-gauge minimum thickness, non-corrosive with a smooth interior surface.



6. Seal all seams and connections with tape or mastic, must be 181B or 181B-M listed material, keeping in mind it may need to be removed for maintenance. Do not use mechanical fasteners, screws, and/or rivets as they will catch dryer lint, creating an obstruction and a fire hazard inside the ducting.
7. Install a dedicated termination with backdraft damper/flapper. Best practice is to install a louvered (three- or four-flapper) hood, as these hoods typically have the strongest air flow and work the best to prevent pest intrusion. Termination may not contain a pest screen.
8. Insulate, to a minimum of R-8, sections of the dryer duct that run through unconditioned space. Exception: Under mobile homes, ensure a downward pitch so moisture may drain outwards.

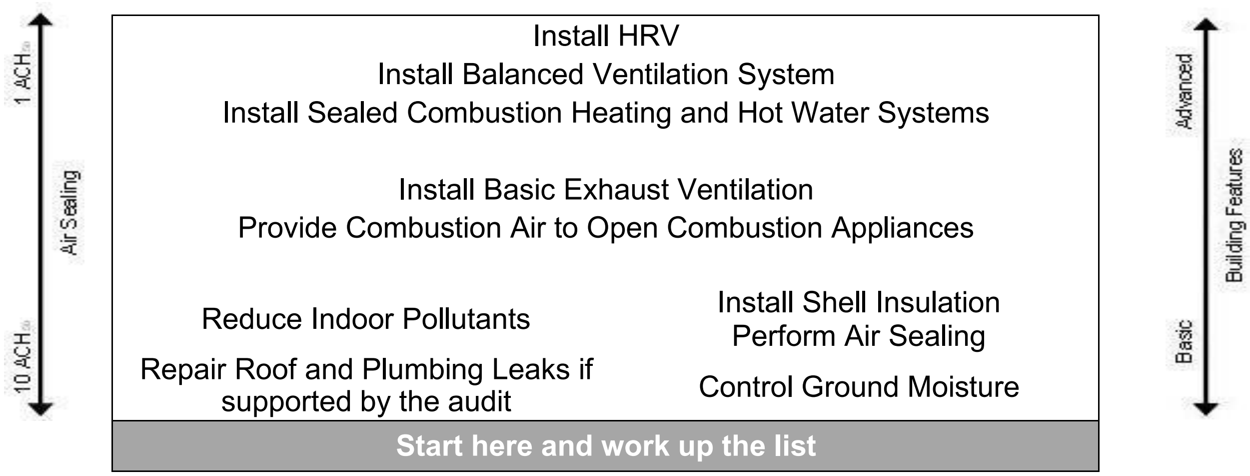
5.14 Priorities for Existing Homes

There are some advantages to designing ventilation systems for existing homes. First, the home provides an observable history from which to work. Stained ceilings, peeling paint, and mildewed attic framing all tell the story of how a building operates. The customer may identify problems not immediately apparent, such as periodic backdrafting of combustion appliances. In addition, the existing home has already aged, allowing lumber to dry and modern materials to out-gas, reducing the pollutant load on the ventilation system.

First, identify any major sources of moisture and other pollutants, and remove them or seal them away from the house. No ventilation system can effectively handle excess amounts of any pollutants.

Complete shell measures to ensure reliable pressure and thermal boundaries. The heating, cooling, and ventilation systems depend on these measures to operate effectively.

The choice of ventilation equipment will depend upon the building's structure, airtightness, customer understanding and commitment to maintenance, and mechanical systems. Many homes may require only exhaust fans. A blower door test and an assessment of the home's existing ventilation will provide the information to determine the home's ventilation needs.



Hierarchy of housing needs: Keep the entire structure in mind as you design and install mechanical systems.

5.14.1 Installation Best Practices

A high level of quality control is needed to ensure ventilation systems work as intended. Properly designed and installed systems help create a healthy indoor environment and a long-lived building, while poorly executed systems can be ineffective or dangerous. Complex central heat-recovery ventilation systems require the most attention to design and installation.

5.15 Radon

Radon is a naturally occurring odorless and colorless gas found in soil and rock. This radioactive gas is formed during the decay of uranium-238 with higher levels found in some areas of the United States. Where present, radon may seep from the ground through openings in foundations and slabs and enter homes. Exposure to radon has been shown to cause health issues for occupants in homes.

5.15.1 Sumps

Some homes have sumps to collect water that infiltrates the basements or crawlspaces. The dictionary definition of a sump is “a pit or reservoir serving as a drain or receptacle for liquids” (https://www.merriam-webster.com/dictionary/sump). In residential buildings sumps can be pre-formed plastic crocks, pre-formed concrete basins, ceramic crocks, plastic buckets, or even holes in a slab or in the dirt floor of a crawlspace. Most commonly, preformed sump crocks are connected to the ground, and often to drain tile water management systems under the slab.[i]

Any sump that is connected to the ground must be sealed (*ASTM:7.3.6.1; AARST:8.5.1*).[i] If a sump is directly connected to the ground such as a hole in the floor of the slab or dirt floor, or if drain tile is connected to the sump, the opening shall be covered with a cover and sealed (SWS 2.0401.2) when applicable (WPN 22-7). When sumps are installed to allow for bulk moisture to drain, a one-way ball valve fitting should be installed if there is enough room (SWS 2.0401.2). Sump covers are required when applicable to help reduce the possibility of radon from entering the home. Covers shall be sealed with silicone caulk or other material that will allow for an air-tight seal, along with any penetrations through the cover. If there is a pump present, it shall be turned off and unplugged prior to any work commencing.

In the event that a sump pump cover is refused or cannot be installed, exhaust ventilation may be installed in the lowest level of the home to reduce the ambient level of radon. Set the flow rate to meet the calculated ASHRAE 62.2 continuous ventilation rate, but no lower than 15 CFM continuous. This installation will then meet the whole-building ventilation requirements for the building. See *Mechanical Ventilation in Chapter 5 – Section 5.12.4 (3)*.

5.15.2 Sump Pumps

Sump pumps come in two styles, either submersible or pedestal pumps. Submersible pumps sit totally submerged in the sump crock. Pedestal pumps have the pump motor extended above the sump crock. In principle, both types of sump pumps operate the same. As the water rises in the sump crock, a float attached to the pump rises until it triggers the pump to turn on and pump water out of the crock. Submersible pumps can have floats that are free floating or that ride up and down on a shaft. The float on a pedestal pump rides on a rigid shaft that extends above the plane of the sump crock.[i]

Submersible pump
(free-floating float)

Submersible pump
(shaft float)

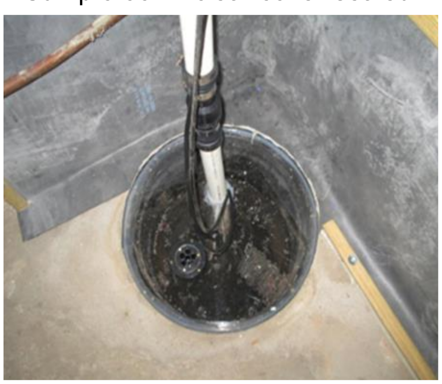
Pedestal pump

Photos courtesy of Dick Kornbluth, LLC

5.15.3 Sump covers for submersible pumps

1. For flat covers, sump pit cover materials must be rigid and made of polycarbonate plastic or other rot resistant material such as pressure treated plywood (*ASTM:7.4.7; AARST:8.5.1*).
2. The covers shall be secured with silicone caulk or if gasketing material is used mechanical fasteners are required such that the cover can be removed. (*ASTM:7.4.7; AARST: 8.2.5*).
3. All sump cover penetrations shall be sealed. (*ASTM: 7.4.8; AARST: 8.5.1*). [i]

Sump crock – clear cover-sealed



Sump hole – clear cover-sealed

Photos courtesy of Dick Kornbluth, LLC

5.15.4 Sump covers for pedestal pumps

There is no way to take the pump apart so holes can be drilled in the cover for the pedestal and rigid tubing that the float is attached to. The tubing would not be able to be sealed since it moves when the float moves. The only options for sealing a sump with a pedestal pump are to.

1. Replace the pedestal pump with a submersible pump and then seal the sump.
2. Install a commercially made cover for the pedestal pump.[i]

Photos courtesy of Dick Kornbluth, LLC

Pedestal pump

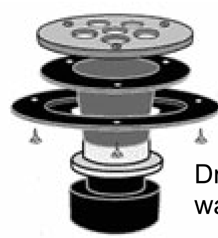
High rise sump cover

5.15.5 Floor Drains

Floor drains are often connected directly to the ground under a slab and not to any waste plumbing. Installing a one-way drain may help reduce the possibility of radon entering the home.

1. Determine if the floor drain is connected to the ground under the slab or to waste plumbing.
2. If the drain is connected to the ground, follow the manufacturer's instructions for installing the appropriate one-way drain.[i]

Dranjer® one-way drain (FR2)



Dranjer® one-way drain (FS2)

Photos courtesy of Dick Kornbluth, LLC

Final Inspection and Quality Assurance Standards

Acceptable installation shall meet the following standards:

1. All Health and Safety measures were completed when appropriate to eliminate or reduce existing hazards or to eliminate or reduce hazards created as a result of the installation of weatherization materials.
2. All appliances passed spillage testing where required and measured CO levels are within standards.
3. No gas leaks are present in building and/or LEL readings are at 0.
4. Ambient CO levels do not exceed 9 ppm.
5. CO alarms are installed where required.
6. Smoke alarms are installed where required.

Ventilation for Indoor Air Quality

1. Whole-building ventilation and local exhaust were installed as required.
2. Measured flow rate of whole-building mechanical ventilation is between 90% and 150% of the ASHRAE 62.2 minimum calculated rate, as determined by the Diagnostic Workbook.
3. Installed whole-building ventilation operates continually or on an intermittent basis with a customer shut-off switch.
4. The customer signed a “refusal of ventilation” when ventilation was declined (DOE funds cannot be used for the job).
5. Ventilation Form filled out completely and left with customer.

Dryer Venting

1. Dryer venting is metal, not plastic, and newly installed venting is UL-listed.
2. Horizontal venting is secured every four feet.
3. Screws or other penetrations that will catch lint were not used to connect ducting.
4. A termination with a damper was used.
5. The vent system is not connected to any other appliance.
6. The damper has no screen to catch lint.

Electrical

1. Covers are present on all junction boxes and flagged if located in attics.
2. Live knob and tube wiring was not covered with installed insulation.

Asbestos

1. Documentation of asbestos safe work is provided as required.
2. Building and surfaces are free of any asbestos debris created by weatherization activities.

Lead

1. Documentation of lead safe work is provided.
2. Building and surfaces are free of any lead debris created by weatherization activities.

Moisture

1. Exposed soil floor is covered with ground vapor retarder. (If not covered, DOE funds cannot be used for the job).
2. Installed dehumidifier is ENERGY STAR and operable.

Radon

1. Sump covers installed.
2. Covers and penetrations are sealed.
3. Covers are moisture resistant.