

122 Water Heaters

Best Practice Recommendations:

- The following tests should be conducted to help assess existing condition of water heaters.
 - Draft test under worst-case draft conditions,
 - CO test, and
 - Gas leak test (gas-fired systems).

1221 Draft Test

The draft test on a gas- or oil-fired water heater must be measured through a hole drilled in the vent connector. For an atmospheric gas-fired unit, drill a hole between the draft hood and the chimney, and in a straight vertical section, if possible. For an oil-fired water heater, drill the appropriately sized hole before the barometric damper and at least six inches away from the water heater unit.

After the water heater has been operating for at least two minutes, insert the probe of the draft device into the hole to the center of the vent connector. Under all conditions, including worst-case, water heaters must demonstrate a minimum draft strength corresponding to the values in Tables 122-1 and 122-2. Notice that draft readings for oil-fired units are not dependent on outdoor temperature – as atmospheric gas-fired units are – because the barometric damper on oil units automatically adjusts for differences in temperature.

Atmospheric Gas Appliances Only					
Acceptable Draft Test Readings for Various Outdoor Temperature Ranges					
Table 122-1					
°F	<20	21-40	41-60	61-80	>80
Pascals	-5	-4	-3	-2	-1
Water Column inches	-.02	-.016	-.012	-.008	-.004

Power Oil Burner Water Heaters	
Acceptable Draft Readings at Breech	
Table 122-2	
Draft Reading Location	Acceptable Draft
Vent Connector	-0.04 to -0.06 inches or -10 to -15 Pascals

1222 Carbon Monoxide Test

With the water heating unit operating for at least two minutes, insert the sampling probe into the appropriate spot in the vent system (before any room dilution air has entered the vent system). For an atmospheric gas-fired unit, the probe must be inserted into the

opening in the draft hood to sample the combustion gases before they are diluted by room air. Readings need to be taken on each side of the vent baffle that divides the integral vent into two sections.

On an oil-fired water heater, check for CO levels at the same hole used to check the draft.

Measure and record the amount of carbon monoxide in the flue gas, either as-measured or air-free. The measured CO level must be equal to or less than that listed in Table 122-3. If cleaning and tuning does not adequately lower the CO emissions, consider replacement of the water heating appliance. See section 2243 for other criteria relating to water heater replacement.

The best time to measure for CO emissions is during worst-case conditions. Please refer to Section 123 for more information.

Carbon Monoxide (CO) Action Levels and Allowable Levels		
Table 122-3		
<i>Appliance</i>	<i>Allowable CO Level</i>	<i>Comments</i>
Gas Water Heater	100 ppm / 200 ppm	as-measured / air-free
Oil Water Heater	100 ppm	as-measured

1223 Gas Leak Testing

Gas leak testing should be done for all natural gas and propane appliance lines and connections. Because propane is heavier than air and natural gas is lighter than air, hold the combustible gas detector probe just below a propane gas line and just above a natural gas line. All identified gas leaks should be referred to appropriate persons for repair or replacement.



**Bacharach Leakator® – 10
combustible gas detector**

123 Worst-Case Draft Testing

Best Practice Recommendations:

- A worst-case draft test should be performed near the end of each work day in appropriate dwellings.
- The worst-case draft test should include:
 - Determination of the worst-case condition in the dwelling.
 - Testing each vented combustion appliance for spillage under worst-case conditions.
 - Testing each vented combustion appliance for adequate draft under worst-case conditions.
- Any appliance that fails the worst-case test before or after all weatherization work is completed should be made non-operational until the hazardous condition is corrected.

1231 Introduction

The purpose of worst-case draft testing is to ensure the proper venting of vented combustion devices in a dwelling. Additionally, carbon monoxide (CO) emissions are measured to ensure they are within acceptable levels.

There are two parts to this important test. For the first part, the assessor establishes the worst-case condition for the Combustion Appliance Zone (CAZ), in other words, finds the greatest magnitude of negative pressure in the CAZ under which the combustion appliances might have to operate. For the second part, the assessor checks for spillage, measures the draft, and determines the level of CO emissions while the dwelling is in worst-case condition.

If a house contains more than one CAZ, a worst-case draft test must be performed for each area. Additionally, if more than one vented combustion appliance is located in a CAZ, each must be tested for safe operation under worst-case conditions.

At the end of each weatherization work day and after the completion of ALL weatherization work, a worst-case draft test must be performed by an assessor or crew foreman. The results must be documented in the job file.



Obvious evidence of drafting failure

If any vented combustion appliance fails the test under worst-case conditions, actions must be taken to correct the cause (see section 12355, “Solutions to Draft Failure or High

CO under Worst-Case Conditions”). After correction, another worst-case draft test must be performed.

1232 Appliances and Dwellings Requiring Worst-Case Draft Testing

Worst-case draft testing should be performed on the following appliance types as specified:⁸

- All Category I gas appliances, both natural draft and fan-assisted, should be tested for spillage, draft, and carbon monoxide emissions.
- All vented oil-fired appliances should be tested for spillage, draft, and carbon monoxide emissions.
- All Category III and IV, sidewall-vented but **NOT** direct-vent/sealed combustion should be tested for CO, but not for spillage or draft. It is recommended that the test for CO emissions be done at the outdoor vent termination.
- All mobile home furnaces should be tested for CO, but not for spillage or draft. It is recommended that the test for CO emissions be done at the outdoor vent termination.

Table 123-1 lists the worst-case conditions testing recommended for various appliance types.

Worst-Case Conditions Testing for Various Vented Combustion Appliances			
Table 123-1			
<i>Combustion Appliance Type</i>	<i>Tests Under Worst-Case Conditions</i>		
	<i>Spillage Test (at 2 minutes)</i>	<i>Draft Test (at 5 minutes)</i>	<i>CO Emissions Test As-measured CO \leq 100 ppm (at 5 minutes)</i>
Gas-fired, Category I, natural draft and fan-assisted	yes	yes	yes
Oil-fired with typical power burner	yes	yes	yes
Gas-fired, Category III & IV, side wall vented, but not direct-vent/sealed combustion	no	no	yes
Mobile home furnaces	no	no	yes

Worst-case draft testing must be done in all dwellings. The following are *exceptions* to this requirement:

- If the house or mobile home is all-electric with no vented combustion appliances, woodstoves or fireplaces.
- If the dwelling has a boiler and/or an atmospheric water heater **and** has no exhaust equipment, including clothes dryers, vented bath and kitchen fans, vented central vacuum systems, fireplaces, woodstoves, etc.

⁸ For a definition of vent categories, please refer to the *National Fuel Gas Code* (NFPA 54), Chapter 3, “Definitions”, “Vented appliance, Category I, II, III, and IV”.

- If the only vented appliances in the dwelling are direct-vent/sealed combustion appliances.
- If the CAZ is located outside of the thermal boundary, such as in a mobile home water heater closet or a garage
- In multi-family buildings with no combustion appliances.

1233 Testing Before Job Completion

In order to ensure that clients are not exposed to the hazards of venting problems between the beginning and completion of the weatherization work, a worst-case draft test should be performed at the end of each work day.

If any combustion appliances fail the worst-case draft test, remedial action must be taken before the work crew leaves the job site for the day. This action might include:

- Correcting the cause of the draft failure or high CO emissions.
- Shutting down the appliance(s) failing the test. This might not always be an option, for example, turning off a heating system during the winter months. Some weatherization programs loan portable electric heaters to clients if heating systems must be temporarily shut down for safety reasons.
- Inform the client of the draft hazard and tell them not to use the appliance until the problem is eliminated by the weatherization organization.



This direct-vent, sealed combustion gas furnace does not require worst-case draft testing

All test results from each day must be documented in the job file.

Caution: Never use the DTL nor the worst-case test threshold values as a substitute for the final worst-case draft test.

1234 Testing After Job Completion

All other diagnostic testing and weatherization work must be completed before the final worst-case draft test is performed. It is particularly important to perform the Duct-Induced Room Pressures Test and correct related problems. Refer to Section 1142 for instructions.

1235 Test Procedure

“Worst-case” is defined as the configuration of the house that results in the greatest negative pressure in the combustion appliance zone (CAZ). Consideration must be given to:

- The types and locations of the heating systems.

- The location and CFM rating of all exhausting equipment (bath fans, dryers, kitchen exhaust devices, etc.).
- The location of wood stoves, fireplaces, and water heaters.
- The volume of the area where the combustion devices are located.
- The location of forced-air system supply registers and return grilles.

12351 Procedure Setup

1. For the final worst-case draft test, duct-induced room pressure testing and adjusting should have been completed Refer to Section 1142 for this test.
2. Place the building in the wintertime condition with all windows and exterior doors closed. If the blower door is set-up, make sure the fan is closed off.
3. Measure and record the outdoor temperature.
4. Deactivate all combustion appliances by turning them off or setting the control to “pilot.” Try to test the appliances with a cool vent system, if possible.
5. Close all operable vents (for example, a fireplace damper).
6. If there is a furnace, replace or clean the filter if it is dirty.
7. Check and clean the lint filter in the dryer.
8. If there are any supply registers in the CAZ, close them.
9. Set up the digital manometer and pressure hoses so that the pressure differential of the CAZ with reference to the outdoors can be easily measured. If the CAZ is in a basement, run a pressure hose to the outdoors through a window or door, and then close the window or door as tightly as possible without totally closing off airflow through the hose. Use masking tape to seal the opening and the meeting rail. Brake lining tubing is also works well as it resists “pinching”.
10. With the interior doors in the conditioned area open, the CAZ door open, and all combustion appliances and exhaust devices off, record the baseline pressure in the CAZ. This is the pressure in the CAZ resulting from stack-effect air leakage. Generally, the colder the outdoor temperature the greater the magnitude of this baseline value. Record the baseline pressure (**P1**).

12352 Determining Worst-Case Conditions

1. Turn on all exhaust devices (except a whole-house exhaust fan). Close all interior doors except those for rooms that contain an exhaust fan, but no supply register. If you are not sure whether to close a door or leave it open, close the door and use smoke to determine which way the air is flowing under the door. If smoke is sucked into the room, leave the door open. If smoke blows out of the room, leave the door closed. Record the pressure in the CAZ (**P2**). The pressure created in the CAZ from the operation of these exhaust devices is the difference between P1 and the baseline pressure, or $P2 - P1$.

Note: If there is a whole-house exhaust fan, it is important to inform the client that operating this fan with the house closed up could be very hazardous.

2. If the house contains a furnace, activate the blower. Record the pressure reading in the CAZ with reference to the outdoors (**P3**). The CAZ pressure resulting from the operation of the exhaust devices *and* the air handler is the difference between P3 and the baseline pressure, or P3 - P1.

Caution: If the only way to activate the blower is to fire the furnace, extreme caution must be used due to the potential for combustion backdrafting or flame rollout. Try to activate the furnace blower without firing the furnace burner. If this is not possible, measure ambient carbon monoxide levels in the CAZ during the test. If ambient CO levels exceed 10 ppm, abort the worst-case draft test and take corrective action.

3. Close the door to the CAZ (this is usually the basement door). If closing this door results in greater depressurization in the CAZ with reference to the outdoors (for example, closing the door changes the pressure from -2 to -4), leave this door closed and record the pressure (**P4**). Leave door open if closing it decreases the depressurization (for example, closing the door changes the pressure from -4 to -3). If the CAZ door is left open, this pressure should be the same as **P3**.
4. Review the results of the testing and determine the dwelling configuration resulting in the greatest negative pressure in the CAZ with reference to the outdoors. Record the worst-case depressurization and its corresponding mechanical systems/doors configuration. This is the configuration – worst-case – to use when checking for adequate draft and CO emissions from each combustion appliance.
5. If there are other Combustion Appliance Zones in the dwelling, find the worst-case configuration for each. Record all data in the job file.



Stand-alone gas water heaters are the most likely appliance to suffer draft reversal

12353 Multiple Combustion Appliance Zones, One with Fireplace

In some cases, it is best to simulate the draft from a fireplace in a dwelling that has multiple combustion appliance zones and one of the zones includes a fireplace used by the client.

Use the blower door to simulate 300 CFM drawn by a typical working fireplace. To do so, place the “B” ring in the Minneapolis Blower Door, Model 3, and increase the fan pressure to 26 Pascals. **Note that this is fan pressure, not house pressure.** Alter the above procedure – Section 12352 – by turning on the blower door (the fireplace simulator) just after activating all the exhaust appliances, but just before activation a furnace air handler, if there is one. Otherwise, proceed with the sequence of the test as instructed in Section 12352.

- 12354 Verifying Proper Appliance Operation under Worst-Case Conditions
1. For personal safety, measure CO in the ambient air while appliances are being tested for proper venting.
 2. Under these worst-case conditions in each CAZ, fire the combustion appliance with the lowest Btu input first to determine if the appliance is drafting properly.
 - a. There should be no spillage of flue gases after two minutes of combustion. If there is spillage after two minutes, the appliance fails the test.
 - b. After five minutes of combustion, the draft should meet or exceed the values in Table 123-2 or Table 123-3. If the values in the appropriate table are not met, the appliance fails the test.
 - c. After five minutes of combustion, measure CO emissions in the vent. Make certain the emissions are measured *before* dilution air enters the vent. As-measured CO should be 100 ppm or less. If CO emissions are higher, the appliance fails the test.
 3. Fire all remaining appliances, one at a time, in order of input rating (smaller to larger), testing each one for spillage at two minutes and draft and CO emissions after five minutes or more.
 - a. If the appliances vent into the same chimney flue or vent connector, test each one individually.
 - b. If the appliances vent into different chimney flues or vents, test with each successive unit running, that is, when firing up the next appliance, allow the previous one to operate. In the case of a water heater, retest the water heater with the other larger Btu input appliances operating.
 4. If the dwelling has other combustion appliance zones, repeat the sequence of activating exhaust equipment, door closure, furnace blower activation, recording pressure readings, etc.
 5. When all worst-case draft testing has been completed, turn off all exhaust equipment and return doors and combustion appliances to their previous operational settings.

Category I Appliances, Natural and Fan-Assisted Acceptable Draft Test Readings for Various Outdoor Temperature Ranges					
Table 123-2					
°F	<20	20-40	41-60	61-80	>80
Pascals	-5	-4	-3	-2	-1
Water Column inches	-.02	-.016	-.012	-.008	-.004

Power Oil Burners Acceptable Draft Readings at Breech	
Table 123-3	
Draft Reading Location	Acceptable Draft
Vent Connector or Breech	-0.04 to -0.06 or -10 to -15 Pascals

12355 Solutions to Draft Failure or High CO under Worst-Case Conditions

If spillage is a problem or if a draft measurement is unacceptable, correct the problem by one of the following methods:

- a. Check for blockage in the vent system and, if found, correct the problem;
- b. Check vent system for leaks, including missing or loose cleanout doors or open or cracked mortar joints. Seal vent system as appropriate. Lining a chimney may solve this problem (refer to Section 225).
- c. Properly seal return duct leakage in the CAZ.
- d. Increase the CAZ air volume by connecting the CAZ to other areas within the conditioned volume of the dwelling (see NFPA 54, NFPA 31);
- e. Increase the CAZ air volume by connecting the CAZ to the outdoors (see NFPA 54, NFPA 31, or NFPA 211).
- f. Install a manufacturers' outdoor air kit for the failed appliances. This is an option with a number of oil-fired furnaces, boilers, and water heaters.
- g. Install fan to supply air to pressurize the CAZ. It is best to link the controls of such a make-up air fan to the operation of the combustion appliance(s) in the CAZ.
- h. For high CO emissions, clean and tune the appliance and test for CO emissions again. Replace appliance if high CO emissions are not correctable.

124 Gas Range Testing

Best Practices Recommendations:

- The following should be completed in dwellings with gas ranges.
 - Inspect the gas range top burners and oven burners for proper maintenance and operation.
 - Measure the range top burners for CO emission levels (as-measured).
 - Measure the oven bake burner for CO emission levels (air-free).
 - Educate the client about gas range use and maintenance.

1241 Introduction

Gas ranges pose a difficult problem for the assessor and the weatherization agency. First, of all the combustion appliances in the field, gas ranges present the greatest challenge for the accurate measurement of carbon monoxide emissions. No other combustion appliance in a dwelling is interacted with as much by clients, making it very difficult to accurately simulate client use during field measurement of CO emissions. In addition, unlike any other combustion appliance in the house, the oven bake burner turns on and off during CO emissions testing, forcing the assessor to be very aware of the cycle during CO emissions testing.

Second, the preferred method of measuring CO emissions from gas oven bake burners requires equipment that measures air-free carbon monoxide. This electronic equipment must be able to measure carbon monoxide ppm and oxygen percentage.⁹ In addition, it is important that the assessor understands that CO is measured in two different ways, “air-free” and “as-measured”.¹⁰

Third, if gas range problems are discovered by an assessor, it might be difficult or impossible to find a qualified technician to repair the appliance.

Use this list to help establish program priorities for protecting clients from any hazard caused by a gas range. The list starts with the most important and ends with the least important.



**Kitchen range, four top burners,
one oven bake burner**

⁹ Two major manufacturers of the equipment that measures air-free CO are TESTO and Bacharach.

¹⁰ Please refer to *Air-Free Carbon Monoxide Emissions from Gas Ranges: Analysis and Suggested Field Procedure*, R. Karg, 1998 for an explanation of as-measured and air-free measurement of carbon monoxide. This document is available at www.karg.com/PDF/files/COairfree.PDF.

- Install at least one CO alarm in a house that has a working gas range (see section 243, “Carbon Monoxide Alarms”). Make sure this alarm is not closer than five feet to the range.
- Inspect the range as instructed below.
- Educate the client about gas range use. See Section 1244, “Client Education”.
- Ensure that your CO test equipment is operating properly and has been calibrated according to the manufacturer’s recommendations.
- Test the oven for CO emissions. Field research has demonstrated that ovens are more likely to be high emitters of CO than range top burners.
- Test range top burners.

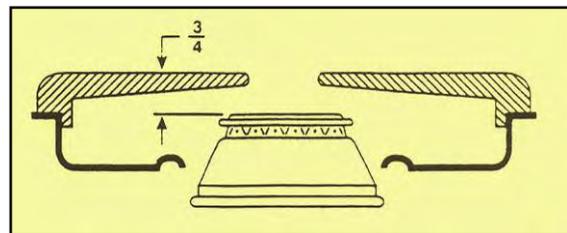
1242 Inspection

12421 General

- Inspect gas range installation for compliance with NFPA 54, the National Fuel Gas Code.
- Check for a flexible gas line connector. If the flexible gas connector can be inspected without moving the range, or if the range is moved out for replacement, make sure the flexible connector is not brass, is not a two-piece connector, and has no pre-1973 rings (in some cases, the date can be found on the flare nuts rather than the date rings). Do not move the range for the sole purpose of inspecting the flexible connector; this movement might crack or otherwise damage it.
- Check for gas leaks at the range top burner area, oven area, and any accessible gas lines with an appropriate combustible gas detector. Check for propane leaks below connections (propane settles) and for natural gas leaks above connections (natural gas rises). If any gas leaks are found, specify repair. Shut off the gas to the appliance and do not proceed with testing until the leak is repaired.
- Check the unit for a pressure regulator. If no regulator is present, check the nameplate for the suggested gas pressure. Measure the gas pressure that is being delivered when the oven is operating. Adjust the gas pressure if necessary.

12422 Range Top Inspection

- Inspect the burners for proper alignment and seating.
- All cooking vessel support grates should be in place, fit properly, and be in one piece.
- If any of the grates are missing or in unsatisfactory condition, the client should not use the affected range burner(s) until the substandard or missing grate is replaced.



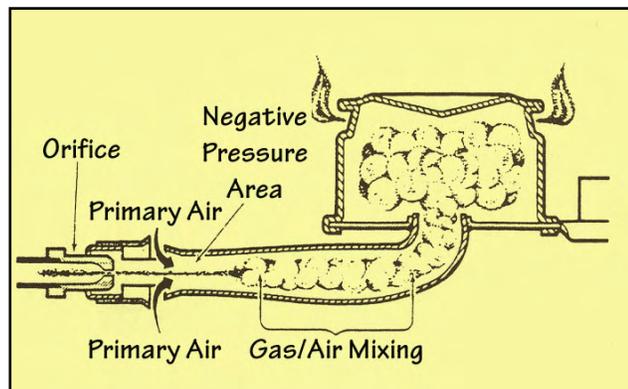
Top of burner should be at least $\frac{3}{4}$ inch below top of grate

- If the range top burners are ignited with a standing pilot light, verify that the pilot flame is present, is about 5/16 in length, and is soft blue in color (not yellow).
- Ignite each burner for at least 30 seconds to inspect its flame for color and noise.
 - The flames should have sharp blue edges with orange specks rising through the flames (dust particles). Make sure there is no significant yellow at the upper tips of the flames.
 - You should be able to hear the gas/flame flow in a quiet kitchen. The sound should not be loud or irregular.

12423 Oven Area Inspection

- Check the oven for blockage of the oven-bottom vents. These vent holes must not be blocked by anything in the oven, such as aluminum foil. The vent openings must never be obstructed because they are an important part of the oven combustion venting system.
- Check for air blockage at the bottom of the range and drawer and/or broiler compartment under the oven. Dust, lint, pet hair, rugs, or any other obstruction blocking free airflow to the oven bake burner must be removed.

- Check the oven bake-burner spreader plate (burner baffle). Most bake burners (the one at the bottom of the oven compartment) have a flame spreader plate just under the oven compartment bottom and above the



Typical range burner operation

bake burner flame (typically, this plate is attached to the oven bottom). Warped or detached spreader plates can result in flame impingement and quenching (cooling) of the gas flame, causing increased production of carbon monoxide. Many spreader plates are intentionally bent into curved or angular shapes, or dimpled, to add strength. Inspect carefully with a flashlight and inspection mirror to determine if the spreader plate has distorted from its original shape or has detached from the oven bottom. Ignite the bake burner to inspect the flame. The flame should not extend beyond the edge of the spreader plate. Also, inspect for carbon buildup on the spreader plate and the oven bottom. Any carbon buildup can be an indication of incomplete combustion caused by flame quenching or a fuel-rich gas mixture.

- If the range also has a broil burner at the top of the oven compartment, check its flame for proper size and color.
- If the oven burner(s) is ignited with a standing pilot light, verify that the pilot flame is present, is about 5/16 in length, and is soft blue in color (not yellow). When properly adjusted, a standing pilot uses about 75 Btuh.

1243 Measurement of Emissions

12431 Safety During Testing

While testing, if indoor air CO concentrations rise above 20 ppm, shut down the burner(s), discontinue testing and open windows and/or doors.

12432 Range Top Burner Emissions Testing¹¹

Test the range top burners after all other appliances have been tested for CO emissions, but before the oven is tested. Test the range top burners as-measured, that is, without adjustment for oxygen content. To test the range top burners:

- Remove all pots and foil from the burners.
- Turn all burners on high and allow them to warm up for at least four minutes.
- Measure the emissions 6 inches above each burner with an open flame.
- Take action based on the table 124-1.

Action Levels for Range Top Burners

Table 124-1

As Measured CO PPM	Measuring Time	Action
< 25 PPM	After 4 minutes of operation	Should be cleaned by client to prevent possible CO problems.
25 to 50 PPM	After 4 minutes of operation	Have appliance serviced.
> 50 PPM	After 4 minutes of operation	Appliance should not be used until either repaired or replaced.

12433 Oven Bake Burner Emissions Testing¹²

Test gas ovens after all other appliances have been tested for CO emissions, including the range top burners. If the oven has a broil burner at the oven ceiling, do not test it for emissions. Only test bake burners located under the floor of the oven. Gas oven bake burners must be tested air-free, that is, with adjustment for oxygen content. To test the over bake burner:

- Remove any items stored in the oven or in the drawer or broiler under the oven compartment. Remove any foil or other extraneous material from the oven floor.

¹¹ This test method is based on the Wisconsin Weatherization test protocol.

¹² This test method is based on the Wisconsin Weatherization test protocol.

- Ensure that self-cleaning features are not activated.
- Insert the instrument probe into the oven vent sleeve so that dilution air will not affect the reading.
- Measure and record a peak reading after at least 15 minutes of oven bake burner operation.
- Take action based on the table 124-2.

Action Levels for Range Ovens

Table 124-2

Air Free CO PPM	Measuring Time	Action
< 800 PPM	After 15 minutes of operation	Should be cleaned by client to prevent possible CO problems.
> 800 PPM, < 1000 PPM	After 15 minutes of operation	Have appliance serviced.
> 1000 PPM	After 15 minutes of operation	Appliance should not be used. Replace appliance.

Note: To protect inspector and customer, continually monitor ambient space around oven during testing.

1244 Client Education

Clients should be educated regarding the safe operation of their gas or propane stoves and ovens.

- The holes in the oven bottom must never be blocked with aluminum foil or anything else. Storing too much in the broiler or drawer area under the bake oven can also block the vent holes. This blockage can result in unacceptable carbon monoxide emissions.
- Do not use the range-top burners or the oven burner(s) as a space heater. Manufacturers recommend against such use; gas ranges are not designed for this.
- If the gas range has a vented range hood above it, the assessor should suggest that the client operate this range hood during oven or range top burner operation.
- If possible, the range should be checked and tuned once every two years by a technician with an instrument capable of measuring carbon monoxide. This checkup and tuning should include:
 - Testing of the range's gas pressure.
 - Making all necessary adjustments for the acceptable operation of all burners. The level of carbon monoxide emissions from a burner can only be



Testing gas oven for CO emission level

determined with an instrument that measures CO and O₂; it cannot be determined by visual inspection of the flames.

- The oven should be kept clean at all times. There is evidence that dirty ovens emit more CO than clean ovens.
- The flames from gas burners – both natural gas and propane – should burn steadily with a clear, blue flame. The flame normally makes a slight hissing sound, but it should not sound like a blowtorch. If the flames burn yellow and/or burn loudly or irregularly, the gas range should be serviced as soon as possible. Avoid using a bad burner until it is properly adjusted or repaired.

130 Health & Safety

Recommended Best Practices:

- Existing smoke alarms should be inspected for proper location and operation and replaced or relocated if necessary.
- Existing CO alarms should be inspected for proper location and operation.
- All homes should receive exterior and interior inspections for previous or existing moisture problems. Weatherization staff should understand the mechanics of moisture movement, the impact that excess moisture has on occupant health and building durability and the impact that weatherization may have on solving or creating moisture problems in homes.
- Existing bathroom and kitchen exhaust fan systems should be examined for actual flow rates, vent condition, exterior termination and controls.
- Dryer vents should be examined for proper vent material, exterior termination and connections.
- Recommended weatherization activities must be done within the context of lead-safe work practices.
- It is the State's responsibility to ensure insulation installed around knob-and-tube wiring be in conformance with applicable codes in the jurisdiction where the work is being performed.

Health and safety issues have become an important part of the Weatherization Assistance Program as knowledge about the hazards within dwellings has increased weatherization measures may make an existing situation worse or create a health and safety problem where none previously existed. The weatherization process presents a unique opportunity to reduce or eliminate existing health and safety issues and ensure that none have been created as a result of weatherization.

It is the policy of the Weatherization Program to address a health or safety hazard when one is discovered. This policy is tempered by recognition that the primary goal of the Program is to conserve energy and that funds must focus on that goal. An important objective is to balance these competing issues by routinely identifying the most important hazards and specifying measures for their abatement.

Health and safety issues should be an integral part of weatherization assessment. The presence, location and operation of smoke and carbon monoxide (CO) alarms should be checked. Health and safety issues related to excess moisture in a home, possible lead hazards and potential electrical problems should also be assessed. Please refer to www.waptac.org for the most recent weatherization health and safety guidance.

131 Smoke Alarms

All weatherized homes should have at least one working smoke alarm. Smoke alarms should be installed as necessary. Test smoke alarm and review testing and maintenance

procedures with clients. For additional information on smoke alarm installation, operation, client education and specifications, see section 241.

132 CO Alarms

Carbon monoxide (CO) is a poison. When inhaled it combines with blood hemoglobin, replaces oxygen in the blood and may completely overcome the body. CO poisoning symptoms include headaches, confusion, dizziness, nausea, vomiting, convulsions, sleepiness, stinging eyes, and loss of muscular control. Death from CO poisoning occurs suddenly. A victim inhaling a toxic concentration of the gas may become helpless before realizing that danger exists.

The effects can vary significantly based on age, sex, weight, and overall state of health. Children, the elderly and the infirm may be seriously affected by even low levels of CO, depending on the concentration and the exposure period.

CO alarms should be installed on every weatherization job where fuel burning appliances are present or when the home has an attached or tuck-under garage. In addition, assessors should have discretion to install carbon monoxide alarms for other health and safety situations.



Smoke – and CO – alarms should be tested monthly to ensure proper battery and electronics operation

For additional information on CO alarm placement and specifications, see section 243.

133 Moisture Assessment

All homes should be inspected for previous or existing moisture problems. Refer to Appendix 130, “Health & Safety Assessment Findings”, to assist identifying mold and moisture related problems in homes.

One of the worst indoor air quality problems is too much moisture in a home. Too much moisture can cause wood rot and promote mold growth. The effectiveness of insulation is diminished when it gets wet. Pests, dust mites, bacteria and virus tend to flourish when indoor relative humidity is too high (greater than 60 percent) and can cause adverse health effects to the occupants. High humidity also increases air conditioning costs because the air conditioner must remove the moisture to improve comfort.

However, some moisture is needed in a home. The lack of moisture in winter air can irritate noses, dry skin, and aggravate medical problems, such as asthma. Wood can dry-out and shrink. The ideal indoor relative humidity during the heating season ranges between 30 and 50 percent. Bear in mind that people create moisture simply by breathing, cooking, bathing, and laundering clothes. In tighter homes, humidifiers usually are not

necessary because of the moisture created by the occupants. Consider removing humidifiers in these homes with the client's permission.

A description of moisture movement mechanisms may be found in Appendix 130.

1331 Symptoms and Types of Moisture Problems

Identifying and solving the source of the moisture should be the first priority when a moisture problem is found. Existing ventilation systems should be checked to ensure that they are functioning effectively. Installing intermittent or continuous ventilation should also be considered to help solve a moisture problem.

Depending upon natural ventilation to solve a moisture problem is not acceptable. The Building Tightness Limit (BTL) should not be adjusted upwards in the hopes that leaving a leaky house will solve a moisture problem.

The following are symptoms of potential moisture problems:

- Mold growth on walls and ceilings, especially in rooms with high moisture loads, such as bathrooms and kitchens,
- Mold in corners or at the wall/ceiling junction (top plate),
- Signs of persistent condensation problems on windows,
- Evidence of water damage or mold on the underside of roof decking,
- Evidence of crawl space moisture,
- Peeling paint, particularly on bathroom and kitchen walls,
- Rusted metal in basements, crawl spaces, bathrooms and kitchens,
- Efflorescence (white, powdery deposits left by water) on concrete or masonry surfaces,
- Musty smell in basement or crawl space, or
- Water stains on foundation walls.

The following list of problems may contribute to the above symptoms.

- Standing water, open sump pumps or dirt floors,
- Leaking plumbing,
- Lack of insulation over top plates or "wind washing" through insulation over top plates,
- Insufficient, poorly installed or lack of insulation in walls and attics,
- Unvented clothes dryer or clothes hung to dry in basement,
- Improper site drainage that causes water to drain into the crawl space or basement,
- Non-operable exhaust fans or exhaust fans not ducted to the outside, and
- No crawl space ground cover.

134 Bathroom & Kitchen Exhaust Fans; Dryer Vents

Moisture should be vented from the spaces in which moisture is generated – bathroom and kitchens. Bathroom and kitchen exhaust fans should be present, operable and vented

to the outside. Fans should have tight fitting backdraft dampers. Non-operable bathroom and kitchen exhaust fans should be replaced. Exhaust fans should be installed in bathrooms and in kitchens that have no fans. Recirculating kitchen fans should be replaced with vented kitchen exhaust fans.

Bathroom and kitchen exhaust fans must be vented to the outside of the building utilizing wall caps, roof jacks or eave mounted termination vents. Fan vents may not terminate in soffits or in attics.

1341 Bathroom Exhaust Fans

Assessors should determine the following:

- Does the fan vent to the outside or into the attic, crawl space or floor cavity?
- What is the type and condition of the exhaust duct?
- How much air (CFM) does the bathroom fan actually exhaust?
- How loud is the fan?
- How is the fan controlled?

13411 Venting

It is common to find bathroom and kitchen exhaust fans that are not vented to the outside of the building. Sometimes these fans are vented into an attic or crawl space. In some cases, the exhaust duct may terminate directly beneath an attic vent. Both of these venting options are unacceptable. In the first instance, moisture is being dumped into an unconditioned space that may result in condensation and building rot. In the second instance, the screen in the attic vent may become clogged with dirt preventing the fan from exhausting properly causing mold growth on the roof sheathing.

13412 Exhaust Duct

Consider replacing exposed flexible plastic exhaust duct with rigid or metal flexible duct. Smooth duct provides less resistance and improved airflow compared with ribbed ductwork. Flex duct should have minimal sag. Turns and bends should be minimized regardless of duct type. Ducts located in unconditioned spaces should be insulated to at least R8. Ducts located in the attic should be insulated or covered with attic insulation.

13413 Measuring Flow

The effectiveness of exhaust fans is based on the power of the exhaust fan, length and type of exhaust duct and cleanliness of the fan grille. When there is excessive resistance in the ductwork, the exhaust fan motor may not be powerful enough to vent sufficient airflow through the duct. The longer the duct length, the greater the static pressure in the duct and the less air flow through the duct.

Just because a fan makes noise doesn't mean that it's functioning properly. It is not uncommon to find noisy fans that are moving no air.

Typical bathroom exhaust fans are generally rated between 50 CFM and 70 CFM.

Actual ventilation rates of bathroom fans can be measured with an Exhaust Fan Flow Meter™. The flow meter consists of a gasketed pan that is placed tightly over an operating exhaust fan. The pan has an adjustable opening and a connection for a digital manometer. The manometer measures the pressure difference between the pan and the house during fan operation. Based on the adjustable opening and the measured pressure difference at the fan, the cubic feet of air per minute (CFM) exhaust by the fan is calculated.

13414 Fan Controls

Replacing controls for bathroom exhaust fans is permitted under weatherization. This may be a desirable measure if high moisture loads are common in the bathroom.

Bathroom exhaust fans may be controlled by a light switch or a separate on/off switch. A single switch assures that the fan operates when the light is



There are many ways to control fans

turned-on. However, when the light is turned-off, so is the fan, even though there may be a significant moisture load remaining in the bathroom. A fan delay timer may be used to replace a switch that controls both the light and the fan. When the switch is turned-on, both the light and fan operate. When the switch is turned-off, the light goes off but the fan continues to operate for an extended period from 1 to 60 minutes (the timer is adjusted on a dial located beneath the cover plate).

A 60 minute timer switch is recommended when the bathroom fan has a separate on/off switch.

13415 Noise

Newly installed bathroom exhaust fans should have a sone rating of 1.5 or less (sone is a rating for sound). Occupants are more likely to use a quiet fan than

a loud one. Most existing bathroom fans will have some ratings significantly higher than 1.5.

1342 Kitchen Fans

Kitchen exhaust fans may be installed as part of weatherization where none exists, when an existing exhaust fan is non-operable or when the kitchen fan is a recirculating type. Kitchen recirculating fans do nothing to remove moisture from the kitchen but may filter the air.

Assessors should determine:

- Does the kitchen fan exhaust outside and not into the attic or crawl space?
- What is the type and condition of the exhaust duct?

Refer to “Bathroom Fan Venting” and “Bathroom Exhaust Duct” for information on proper exhaust fan duct types and termination points.

1343 Dryer Vents

Installing or correcting dryer venting is also permitted under the Weatherization Program. The following dryer conditions may be corrected.

- Disconnected dryer vent,
- Termination of the dryer vent to a space other than to the outside of the building,
- Plastic ribbed dryer vent,
- Venting fastened with screws or rivets, and
- Improper dryer vent cap (no screen or wire cap).

See section 245, “Dryer Venting”, for information in proper dryer venting procedures.

135 Site Drainage

Poor site drainage is often the reason for wet foundations (basements, crawl spaces and slabs). Homes that have wet foundations often have mold and moisture problems within the living space. To keep the foundation dry, the soil in contact with it must be kept dry.

It’s recognized that weatherization dollars are limited and correcting a site drainage problem may be outside both the budget and scope of weatherization services. However, the following guidelines are presented to assist assessors in identifying causes of wet foundations and the resulting mold and moisture issues resulting from these conditions. Recommendations are provided to help solve site drainage problems.

Look for areas around the home where rainwater may collect – damage is worse where greater quantities of water are concentrated. A valley on a roof acts like a funnel, with the greatest concentration of water at the base of the valley. Gutters act like funnels that collect water from the edge of the roof and concentrate it in the downspout.

Check for the following items regarding site drainage.

- Do site conditions direct rainwater or snow melt toward the foundation rather than away from it?
- Are there localized depressions adjacent to the foundation?
- Do sidewalks or paved drives direct water toward the foundation rather than away from it?
- Are there raised plant beds that collect and hold water?
- Are there site features such as valleys and swales that concentrate the water on the site?

Remember the “ground-roof” rule¹³ - the soil surface should be viewed as a low-slope roof surface. The surface should be pitched away from the home – the steeper the pitch, the better the drainage. Imagine all the water moving to the low edge of the site, and imagine how best to get it there is the best way to approach solving a site drainage problem.

Specific site drainage guidelines include:

- The house should be built on a crown, not in a hole. If there is sufficient exposed foundation, site grading at the house can be improved. If the house hugs the ground, improvements at the foundation are more difficult. There should be a minimum of 8 inches of exposed foundation between the ground and the beginning of the siding.
- The soil adjacent to the foundation should be sloped away from the house at a minimum of 5 percent. Six inches of fall in the first 10 feet away from the house provides a 5 percent slope.
- Identify localized dips and holes immediately adjacent to the foundation and fill with dirt. Tamp the fill material to prevent future settling. Provide sufficient fill material such that drainage occurs away from the foundation.
- If the house has no gutters, then the base of the soil around the house has to serve as a gutter itself. It should have a surface that helps prevent splash back onto the siding of the house. It should be designed with pitch so that it effectively moves water away from the house.
- Good tamping or compaction of the backfill is very helpful because it slows water absorption by the subsurface soil.
- Bushes and other plantings may be very helpful, especially if their root balls soak up water. Also they can be planted strategically near downspouts so that the downspout extenders are less likely to be kicked off or removed during lawn mowing.

136 Gutters and Downspouts

Gutters and downspouts can be an important part of solving a site drainage problem. They provide a means of collecting rain water and distributing it away from the foundation.

¹³ The “ground-roof” is a concept developed by the Building Research Council at the University of Illinois – Urbana Champaign

Check for the following when evaluating a gutter system.

- Is there a gutter system? Gutters are not standard in all states in this weatherization region because of maintenance issues (gutters get clogged with leaves) or ice dam issues (gutters become damaged). Gutter guard systems are available to help keep gutters clean. Bypass sealing, properly insulating over top plates and a properly insulated attic can help solve ice dam problems.
- Gutters should be pitched to the downspouts. There should be no more than a 40 foot length of gutter without a downspout. Short gutters may be level. In areas where tree leaves might cause clogging, gutters and downspouts should be oversized so that leaves and debris will be flushed more easily. Gutter hangers should be strong enough to keep gutters from sagging.
- Downspouts should be securely fastened to the house. Elbows and straight sections should be fastened together with pop rivets – screws that project into the downspout can lead to clogging.
- At the base of the downspout, the water must be directed away from the foundation of the building by 3 to 5 feet. If water is allowed to dump close to the foundation, it might cause moisture problems in the dwelling. The good way to discharge the water away from the house is with downspout extenders (sections of straight downspout) or splash blocks. Both of these are often disturbed when lawns get mowed. A notched section of downspout that is hinged to the elbow at the base of the downspout can solve this problem.



Gutter and downspout

137 Lead

Lead paint is the primary source of lead in a homes built before 1978. After 1940, paint manufacturers voluntarily began to reduce the amount of lead they added to their consumer paints. As a result, painted surfaces in homes built before 1940 are likely to have higher levels of lead than homes built between 1940 and 1978.

Lead paint was not used in the manufacture of mobile homes, but may be found in varnishes and stains in mobile homes remodeled before 1978.

Ingestion or absorption of lead into the blood stream over time is a serious health hazard causing brain damage. This can be a particularly serious with small children who may ingest lead contaminated dust or paint chips. This contamination is more likely to occur when lead paint is disturbed by sanding, chipping, or flaking.

Workers can be contaminated in the same way as children, but are most likely to be exposed by breathing dust created by sanding or planing surfaces that contain lead based paints.

All Weatherization Program activities involving renovation work on pre-1978 dwellings are subject to the provisions of the Federal Environmental Protection Agency (EPA)¹⁴. This regulation requires that an informational pamphlet that explains the hazards of lead paint chips and dust be given to the occupants of the dwelling. This pamphlet must be given to the owner or occupants of the dwelling prior to starting the work, but not more than 60 days before the work begins. Assessors should review this pamphlet with the occupants at the time of assessment. Assessors should explain to occupants that lead-safe work practices will be used when work is being done on their home.

Please refer to your state weatherization office for more details about lead-safe work practices. For detailed information regarding lead safe weatherization practices, see <http://www.waptac.org/sp.asp?mc=tech aids health lead>.

If weatherization work is being done in HUD-assisted housing, HUD's requirements regarding lead safe practices must be followed. These practices are more rigorous than DOE's lead safe practices.

138 Electrical

Electrical safety is an important health and safety concern, especially in older dwellings. Correcting electrical wiring problems is generally an allowable weatherization health and safety expense. Service boxes, fuses/breakers, and wiring should be inspected as part of the house assessment to ensure problems are brought to the attention of the client. If it is determined that a hazardous situation exists with wiring, breakers, or other parts of the electrical system, the client, agency or contractor must correct the problem before weatherization work begins.

- Check for proper sizing of fuses/breakers to wiring size in circuit panel boxes.
- Identify any wiring in the circuit panel box that is aluminum (except for main service connections).
- Inspect circuit panel box for multiple circuits connected to individual breakers or fuses. Inspect for disconnected or loose wiring inside the box.
- #14 copper or #12 aluminum wiring should be protected by a fuse or breaker rated for no more than 15 amps. #12 copper or #10 aluminum should be protected by a fuse or breaker rated at no more than 20 amps.
- Ensure that the circuit panel/fuse box has a secure cover.
- Test all outlets for proper grounding. Identify circuits which contain non-grounding devices. Inspect for ground fault interrupter (GFIC) devices in kitchen,

¹⁴ The lead paint notification requirement is an EPA requirement and is addressed in 40 CFR (Code of Federal Regulations) Part 745, titled, "Lead; Requirements for Hazard Education Before Renovation of Target Housing."

bath, laundry, unfinished basements and pool areas. Test GFIC's for proper operation.

- Inspect for frayed wiring, improper splicing and lack of junction boxes or covers. Wiring splices must be enclosed in approved metal or plastic electrical boxes, fitted with cover plates.
- Record problems found on a building analysis form.
- Identify appliances posing potential electrical shock hazard.

Notify homeowner, in writing, what problems exist and make notation of this in the file.

1381 Knob-and-Tube Wiring

According the National Electrical Code (NEC) 2002:

“Concealed knob-and-tube wiring is designed for use in hollow spaces of walls, ceilings, and attics and utilizes the free air in such spaces for heat dissipation. Weatherization of hollow spaces by blown-in, foamed-in, or rolled insulation prevents the dissipation of heat into the free air space. This will result in higher conductor temperature, which could cause insulation breakdown and possible ignition of the insulation.”

Insulating over knob-and-tube wiring would be a violation of the NEC and place weatherization subgrantees at risk for liability where the cause of a fire could be traced to insulation in contact with knob-and-tube wiring.

However, according to a study by the Weatherization Training Center at Pennsylvania College of Technology¹⁵:

Properly installed and unaltered K&T wiring is not an inherent fire hazard. The research shows that insulating over knob and tube wiring, when that wire is free of problems is rarely a fire hazard. However, insulating over wires can be a critical contributing factor to creating a fire hazard when other problems such as loose connections or excessive electrical loads, are present.



Knob-and-tube wiring can be hidden under attic floors; don't forget to inspect for it and then treat it accordingly

A number of states and local municipalities have amended the NEC to allow for insulating over knob-and-tube wiring, given that certain precautions are first taken. Therefore, the official DOE-WAP policy on installation of thermal

¹⁵ “Retrofitting Knob and Tube Wiring – An Investigation into Codes, Assessment, Wiring Practices and Cost” for the Pennsylvania Department of Community and Economic Development, January 2004

insulation around knob-and-tube wiring is that it is the State's responsibility to ensure that such work is in conformance with the applicable codes in the jurisdiction where the work is being performed.

The following protocol is recommended when knob-and-wiring is found in building cavities where insulation is being planned.

Qualified electrical technicians should assess the condition of the electrical system and its alterations. If knob-and-tube wiring has been deactivated and the dwelling has been rewired with BX, Romex, or other approved electrical cable, insulation may be placed around and in contact with the inactive knob-and-tube wiring.

If the knob-and-tube wiring is active, personnel authorizing work orders or contracts shall arrange for, or conduct a thorough inspection of, the areas to be insulated before approving insulation around live knob-and-tube wiring, and make sure that:

1. All live wiring to be covered is examined and tested to ensure that the voltage drop is 10 percent or less.
2. The electrical system has protective devices matched to the wire sizes and which stop the flow of electrical current if the circuits are overloaded.
 - Number 14 wire shall be fused with 15 amp fuses.
 - Number 12 wire shall be fused with 20 amp fuses.
 - "S" type fuses or breakers must be installed in the electrical panel serving any knob-and-tube wiring.
3. Documentation of items 1 and 2 must be kept in the job file.

If, for any reason, the above items cannot be completed, all insulation must be kept at least 3 inches from the knob-and-tube wiring unless the wiring has been approved or upgraded by a licensed electrician.

Additional information regarding the history of knob-and-tube wiring and the NEC as well as the Weatherization Assistance Program's policy may be found in "*Retrofitting Insulation in Cavities with Knob-and-Tube Wiring - An Investigation into Codes, Safety, and Current Practices*"¹⁶.

¹⁶ Jeffrey R. Gordon, Building Research Council at the University of Illinois at Urbana/Champaign, for the Illinois Department of Commerce and Community Affairs, June 2000.

211 Air Sealing

Best Practices Recommendations:

- The primary objective of air sealing is to establish an effective air barrier at the thermal boundary of the home.
- The benefits of air sealing must be balanced with maintaining acceptable indoor air quality and ensuring proper draft of combustion appliances.
- Blower door tests should be performed during air sealing activities to help guide those tasks.

Air leakage reduction is one of weatherization's most important functions, and often the most difficult because of having to balance energy savings against creating indoor air quality problems. Objectives of air leakage reduction are to:

- Protect insulation's thermal resistance to save energy,
- Avoid moisture migration into building cavities, and
- Increase comfort.

Simultaneously, one must ensure that the home is not made too tight. The home must remain healthy and combustion appliances must vent properly.

The ultimate goal of air leakage reduction is to establish an effective air barrier. Establishing an effective air barrier and follow-up blower door and draft testing will meet these objectives.

2111 Air Movement

Air leaks into and out of a home by three main ways:

- Bypasses, which are significant flaws in the home's air barrier,
- Seams between building materials, and
- Leaks in building materials themselves.

Two things are required for air to move into and out of a home – a hole and a pressure difference from one side of the hole to the other. Remove one, and air will not flow. For example, no air will flow through an open window (hole) unless the wind is blowing (caused by a pressure difference). The larger the hole and the greater the pressure difference, the greater the amount of air flowing through the hole.

The first rule of air sealing is: Seal the big holes first. Leaks at the building's high and low points generally see more pressure, so they have a higher priority. Small leaks through door and windows may seem dramatic when depressurizing the home with a blower door because of the high air velocity through these small cracks. However, the less obvious air leaks are usually more important leaks, because they are larger or because they are under a greater pressure by being located in attics and basements or crawl spaces. This type of air movement is called the "stack effect".

Generally, trying to reduce infiltration caused by the stack effect is more important than trying to reduce heat loss caused by the wind. Unlike wind that varies in strength and direction, stack is constant during the heating season. There is a constant temperature difference (hence, pressure difference) between the conditioned space and the attic cavity. Reducing stack has the greatest impact on saving energy (keeping warm air in the house), increasing comfort (less draft near the base of the home), protecting the insulation's thermal resistance (air flow through insulation reduces its R-value) and keeping moisture out of building cavities (warm air moving out of a house during the heating season carries moisture with it).

2112 Sealing Bypasses

Bypasses are holes and gaps in the air barrier. The effort worth expending to seal a bypass depends primarily on its size and location. In general, the larger the hole near the top or base of a home, the greater the air leakage reduction will be when it's sealed.

Bypasses are found between the conditioned space and attic, conditioned space and crawl space, conditioned space and attached garages and conditioned space and the outside.

Start by sealing the larger bypass openings first to achieve larger air leakage reductions. There will be cases where sealing an important bypass won't necessarily reduce air leakage. For example, a chaseway in a plumbing wall tightly sealed from the house but very leaky to the attic acts as an insulation bypass without actually leaking air between the house and the attic. Even though the house air leakage may not be reduced, the attic insulation performance will improve after this attic bypass is sealed.



A significant air bypass in a closet up into a sloped ceiling through plaster and lath

It is always preferable to use strong air barrier materials like plywood, drywall or rigid foam insulation board to seal bypasses (see section 2114, "Air Sealing Materials"). These materials should be attached with mechanical and/or adhesive bonds. Strong materials with strong bonds are best practice because air barriers must be able to resist large pressure differences. Smaller bypasses may be sealed with expanding foam or caulk. In all cases, air sealing materials used in areas visible to the client should be complementary to the surrounding

finish. Air sealing materials should be used in a manner that does not degrade the appearance of the home.

Sometimes bypasses are easily accessible and sometimes not. When they are not easily accessible, dense-packed cellulose insulation may be blown into surrounding cavities. The cellulose will resist airflow and clog cracks between building materials.

The following are some examples of bypasses and how to seal them. A more comprehensive bypass list follows. All bypasses are to be sealed prior to insulating except where they cannot be reached cost effectively.

2113 Bypass Types

- Joist spaces under knee walls in finished attic areas: Connect knee wall air barrier to ceiling air barrier by creating a rigid seal under the knee wall or by blowing short sections of the floor cavity with densely packed cellulose. Blocks of 1 inch rigid foam board insulation may be cut and placed between ceiling joists. Seal perimeter of foam blocks with expanding foam.
- Kitchen or bathroom soffits: Seal the top of the soffit with plywood, gypsum board or foil-faced foam board insulation; fasten and seal to ceiling joists and soffit framing with expanding foam or caulk.
- Two-level attics in split-level houses. The wall between the upper and lower levels of the house is often open to the attic of the lower house section: Seal the wall cavity with a rigid material fastened to studs and wall material.
- Tops and bottoms of balloon framed interior partition wall cavities, missing top plates: Seal with ¼ inch plywood, gypsum board or foil-faced foam board insulation and caulked or foamed to surrounding materials.
- Joists between floors: air seal around perimeter of building at bandjoist areas with high density insulation or apply spray foam.
- Chimney passing through attic floor: Seal chimney and fireplace bypasses with sheet metal (minimum 28 gauge thickness) and seal to chimney or flue and ceiling structure with high temperature sealant or chimney cement.
- Soil stacks, plumbing vents, open plumbing walls: Seal joints with expanding foam or caulk. If joint is too large, stuff with fiberglass insulation and foam over the top.
- Housings of exhaust fans and recessed lights: Caulk joints where housing comes in contact with the ceiling (see note below for boxing and air sealing around recessed light – additional information may be found in section 2121 under “Attic Insulation”).



Plumbing stack sealed with foam

- Duct boots and registers: Caulk or foam joint between duct boot or registers and ceiling, wall, or floor finish if ducts are located in attic, crawl space or attached or tuck-under garage.
- Wiring and conduit penetrations: Seal with caulk.
- Duct chases: If chase opening is large, seal with rigid barrier such as plywood, drywall or rigid foam board insulation and seal to ducts and ceiling materials. Smaller openings may be foamed or stuffed and caulked.
- Bathtubs and shower stalls: Seal from crawl space or basement with expanding foam or rigid material for larger openings.
- Attic hatches and stairwell drops: see section 2122, “Preparation” under “Attic Insulation” (section 212).
- Other openings in the air barrier: Seal with rigid material, caulk or expanding foam depending upon size of opening.

Typical attic bypasses include the following.

- plumbing chase
- plumbing soil stack
- furnace flue chase
- missing top plate (interior walls)
- missing top plate (exterior walls)
- wire penetrations
- exhaust fans
- ceiling mounted junction boxes
- recessed lights
- fireplace/chimney chase
- missing fireplace damper or poorly fitting damper
- soffits above interior cabinets
- dropped ceilings
- stairway dropped ceiling
- attic stairway stud spaces
- whole house fan
- joist spaces beneath knee walls
- attic floor level changes (two level attics)
- area above laundry chute
- dumb waiter shaft
- duct plenum
- duct penetrations (wall and ceiling)
- plaster lath voids
- attic hatch
- fold away attic stairway



This blocking allows too much space around this recessed light; insulation must be kept just three inches away

Typical bypasses found at the base, or foundation, of a home include the following.

- plumbing stack
- bathtub trap

- wiring penetrations through floor
- plumbing penetrations through floor
- duct shafts
- duct penetrations
- chimney or flue
- balloon framing wall/ceiling cavity
- basement/crawl space or slab interface
- wiring penetrations
- utility entries
- wiring penetrations to outside
- crawl space vents
- crawl space hatch
- dryer vents
- cores of concrete block exposed at sill plate
- sill plate
- foundation cracks or holes

Bypasses found in the main part of a home are less important as related to the stack effect. However, sealing holes in the middle part of the house will reduce air leakage caused by wind and may improve comfort. Common bypasses found in the middle of the home include:

- drop ceiling (between floors)
- floor trim
- ceiling trim
- outlets/switches
- wall mounted fixtures
- wall mounted exhaust fans
- medicine cabinets
- plumbing penetrations beneath kitchen sink
- plumbing penetrations beneath bathroom sink
- bathtub cutouts
- plumbing access hatch
- vents under fixed windows
- permanent window air conditioners
- cracks or holes in exterior walls
- panned returns, floor cavity
- panned returns, wall cavity
- hollow walls for fish tanks, stereo, etc.

Window and door infiltration reduction measures are found in sections 215 and 216, respectively.

21131 Recessed Lights

Box around recessed light fixtures to prevent overheating and/or fire. Use gypsum board to construct the box. Provide a minimum 3 inch clearance between the box and the sides of the fixture. The box should be constructed to a height that will be

4 inches above the installed insulation. Cover the box with gypsum board and seal to the sides of the box. The box is not to be covered with insulation. If there is insufficient clearance to install a box 4 inches higher than the insulation, do not cover the box and use an appropriate barrier to keep the insulation 3 inches away from the fixture.

Recessed incandescent fixtures may also be replaced with IC rated fluorescent fixtures if cost effective. Replacement fixtures should be ENERGY STAR® rated.

2114 Air Sealing Materials

Materials used to seal air leakage sites must be nearly impermeable to air movement as possible and form a continuous, nonporous surface over the opening being sealed.

- **Caulks/Sealants**
Caulk should be applied according to the manufacturer's instructions. Caulk should be applied to a smooth, clean, dry surface. It should always be applied in a continuous bead and free of voids, with a smooth and neat appearance. Excess caulk should be removed before it cures.



Foil faced bubble wrap may NOT be used for sealing chimney chases.

All openings 3/8 inch to 7/8 inch wide should be filled to within 1/2 inch of the surface with an appropriate packing material specifically manufactured as a packing material prior to caulking. All packing material should be compatible with the type of caulk used.

- Latex/Acrylic/Silicone Hybrids – must conform to ASTM C834
 - Acrylic (solvent type), Chlorosulfonated Polyethylene – must conform to F.S. TT-S-00230C
 - Butyl Rubber – must conform to F.S. TT-S-001657
- **Packing Materials**
Packing materials used to fill gaps too large for caulks or sealants to seal properly must be flexible closed cell or otherwise nonporous materials that will not absorb moisture and will remain flexible at low temperatures. Packing materials include flexible polyurethane, oakum, butyl rod or similar foam rod stock.

Fiberglass is not to be used as an air sealing material, but may be used to stuff larger openings as a backer material with spray foam applied over the

top of it. Tops of open wall cavities may also be stuffed with fiberglass which will be dense packed with insulation.

- Weatherstripping
Weatherstripping around doors and windows, including window channel, door sweeps and thresholds must be mechanically fastened in place. Felt and flexible foam weatherstripping need not be mechanically fastened. Flexible foam adhesive-backed weatherstripping may be used to seal ceiling mounted attic accesses.
- General Air Barriers
The following air barrier materials shall be used for the following conditions.
 - Polyethylene
Should have a minimum thickness of 6 mil and be used as an interior barrier material when moisture must be kept out of the conditioned space.
 - Spun olefin (*Tyvek, Typar, etc*)
Spun olefin membrane air infiltration barrier should be used when moisture must escape from the conditioned space. These materials are not recommended for use in a location where they remain cool for most of the year, such as the floor above the crawl space or basement ceiling. Water vapor will not move through these materials if they are at or below the dew point temperature.
 - Wood or wood composites
Wood or wood composites should be used where flame retardant characteristics are not important. When exposed to moisture or weather, all raw exposed wood must be an exterior grade material and primed on all sides.
 - Gypsum board
Gypsum board should be used in interior applications where excessive moisture is not a problem and where flame retardant abilities are important.
 - Rigid foam board insulation
Air sealing materials such as rigid foam board must be sealed in place with caulk or non-expanding foam to make it air tight. Polystyrene shall conform to ASTM C576. Polyurethane and polyisocyanurate with foil facing shall conform to F.S. HH-1.
 - Metal flashing

Metal flashing should be used when high temperature or high moisture is a factor.

- Special air barriers

Specialty air barrier materials include such items as electrical outlet gaskets and plugs, window pulley gaskets and interior wall patching materials.

212 Attic Insulation

Best Practice Recommendations:

- Attics should be thoroughly inspected for safety and moisture related issues. Such issues should be addressed prior to installing attic insulation.
- Effective R-value of existing attic insulation should be determined taking into account age, settling, gaps and voids and uniformity of coverage.
- Unfinished Attics
 - Blown insulation is recommended for unfinished attics cavities and should be installed to a uniform depth according to manufacturers' specifications for proper coverage.
- Cathedral ceilings should be dense-packed with insulation.
- Finished Attics
 - Collar beams and outer ceiling joists should be insulated as per unfinished attics.
 - Sloped ceiling should be dense-packed with insulation.
 - Knee walls should be insulated to the maximum R-value as allowed by stud cavity depth. A vapor permeable air barrier should be used to enclose the back-side of the knee wall cavity.
- Attic ventilation should be part of an overall strategy for controlling attic air temperatures and should be considered an optional measure.

Attic insulation in older homes is often both insufficient and ineffective. Even if insulation levels look sufficient, the insulation may be ineffective due to poor installation (particularly batt insulation). Blown insulation may have settled. Sections of the ceiling may be uninsulated due to work related activity or wind-washing through vents. Rooms added to an attic may have uninsulated knee walls or collar beams. Gaps may exist in the attic insulation between the house and room additions. Furthermore, attic bypasses and their effect on insulation performance were unknown when many of these attics were originally insulated.

Installing attic insulation provides a number of benefits to the client besides energy savings. Comfort may be increased while decreasing moisture problems, including ice dams. But attic insulation must be installed in a proper and safe fashion to be effective.

2121 Safety

21211 Heat Producing Devices

Comply with fire and electrical safety procedures before insulating.

- Note all electrical devices which require safety clearance shielding, such as recessed lights without Type IC (insulation contact) rating, vent fans, flues, chimneys, door bell transformers and other heat producing devices.
- Install noncombustible barriers (i.e., metal or unfaced mineral fiber batts) around all heat producing sources to permanently maintain a

minimum 3 inch dead air space. All barriers should extend at least 4 inches above the height of the finished insulation.

- Metal used as a barrier around heating producing devices or chimneys must be fastened securely to attic joists in such a manner as to not allow the barrier to collapse. The metal must be 26 gauge galvanized and be sealed with high temperature caulk to the chimney and surrounding framing and finish materials.
- Clearance of insulation from attic furnaces must be provided in accordance with the governing code.
- Box around recessed light fixtures with gypsum board to prevent overheating and/or fire. Provide a minimum 3 inch clearance between the gypsum board box and the sides of the fixture. The box should be constructed to a height that will be 4 inches above the installed insulation. The box is not to be covered with insulation. If there is insufficient clearance to install a box 4 inches higher than the insulation, do not cover the box and use an appropriate barrier to keep insulation 3 inches away from the fixture.
- The perimeter of attic fans should be dammed with 1 inch thick common lumber, plywood or metal shielding.
- Wood-stove manufactured chimneys should have ventilated insulation shields.

21212 Knob-and-Tube Wiring

A home may have been rewired and the knob-and-tube (K&T) wiring left in place. It must be confirmed that the K&T wiring is not in service before covering it with insulation.

See section 1381, “Knob-and-Tube Wiring”, for recommendations for insulating over active knob-and-tube wiring.



Even if there is attic flooring, knob-and-tube wiring and attic bypasses must be found and treated before insulation is added

If the recommendations cannot be implemented, isolate K&T wiring in a permanent manner with a minimum 3 inch air space below and to the side of the wiring. All barriers must be permanently secured and made of materials that are consistent with building and fire code requirements. Do not blow insulation into floor cavities with live K&T wiring. When insulating above such cavities, make sure to seal the ends of the cavities to eliminate thermal bypasses.

Active attic K&T wiring may be replaced to achieve maximum attic insulation R-value if it can be done as 1) an incidental repair cost with DOE funds, 2) with non-

DOE funds or 3) as part of the total attic insulation measure if the cost of both replacing the K&T wiring and adding insulation are cost effective.

21213 Pests & Animals

Document the presence of any animal or insect pests in the attic. Note the presence of any animal or bird feces that may pose a health threat. Determine measures or personal protective equipment necessary to ensure the safety of weatherization workers in the attic.

2122 Preparation

21221 General

Review condition of ceiling. Ceilings must be able to support the added weight of insulation. Closed electrical junction boxes may be covered with insulation, if appropriately marked. Seal all holes to keep animals (birds, rodents, bats, etc.) out of the attic. Document poor ceiling conditions with digital photographs.

Note stored boxes or objects that may obstruct weatherization work. Consult with the client about removing these items. If the client is unable or unwilling to do this work, determine if it is feasible for weatherization workers to remove obstructions and obtain permission from the client.

21222 Bypasses

Check for completion of bypass sealing before installing any insulation. Remember that attic insulation is not an air barrier. Document the location of chaseways containing utility runs or ductwork in the sidewalls if any.

Seal joist spaces under knee walls by creating a rigid seal between the floor joists under the knee wall or by blowing short sections of the floor cavity with densely packed cellulose.

See section 2112, “Sealing Bypasses”, for additional information regarding attic bypasses.



Some attics require much preparation work before they can be blown with cellulose

21223 Mechanical Systems

All attic ductwork must be sealed prior to insulating (see section 2271, “Duct Sealing”). All attic water lines must be kept on the warm side of attic insulation.

21224 Moisture

Examine attic for moisture problems due to roof leaks, including missing or damaged flashing. Repair all roof leaks before insulating attic. If roof leaks cannot be repaired, attics are not to be insulated.

Inspect sheathing and rafters for discoloration, mold or rot. Note location of damage. Note interior plaster or gypsum board damage due to moisture problems in attic. Try to identify source of moisture and determine if corrective action can be taken under weatherization.

All kitchen and bath fans currently venting into the attic must be equipped with backdraft dampers and vented outdoors through roof or eave fascia boards. Fans without operating dampers should be repaired or the fan should be replaced with a low sone fan. Ribbed plastic vent material from bathroom and kitchen exhaust fans should be replaced with rigid aluminum, galvanized pipe whenever possible or flexible metal. Vent pipe should be insulated to prevent condensation. Additional information regarding proper bathroom and kitchen fan ventilation may be found in section 2442, "Ventilation".

Inspect all flat or low-pitched attic sections that will be dense-packed with insulation to make sure that problems or hazards do not exist. Determine if corrective action measures are needed prior to installing insulation.

21225 Top Plates

Existing batt insulation over top plates should not be compressed with scrap wood or gypsum board. Remove compressed or ineffective insulation over top plates.

Eliminate wind washing through insulation where soffit venting exists. Block cavity over top plate to prevent blown insulation from falling into soffit and to maximize insulation over top plates. Cavity may be blocked with two-part spray foam, rolled fiberglass insulation or other rigid materials.

Mechanically fasten eave chutes between foam or blocking and roof sheathing to maintain ventilation passageway. Chutes or blocking material should not compress insulation.

In rafter cavities where a chute is not installed, ensure that cavity is blocked with a rigid barrier as described above to prevent over-spill into the soffit area. Where possible, place eave chutes in every rafter cavity that is vented. Chutes must be long enough to extend above the level of the finished insulation.

2123 Attic Access

The following information pertains to access to unfinished attics. See section 21265, "Knee Wall Hatch" for access to knee wall attics.

21231 Installation

Attic access openings may be installed to attics where access openings are not present. Interior access panels are not required if gable vents are large enough for attic access.

Attic hatches installed during weatherization should be large enough for a person to pass through and allow for a thorough inspection of the attic. Openings must be at least 4 square feet and at least 20 inches in width or length. Attic hatches must not be permanently sealed.

Install permanent blocking around ceiling attic hatches to prevent insulation from falling through openings. The blocking's purpose is to prevent loose-fill insulation from falling out of the attic when the attic hatch is opened. Rigid materials like plywood or OSB board should be used and be installed such that they will hold the weight of a person entering or exiting the attic. Window casing may be used as interior trim around ceiling access panels. Joints in the casing should be caulked prior to painting.

21232 Hatch Insulation & Air Sealing

Hatches to attics should be insulated to the attic insulation level. Hatches should also be air sealed with weatherstrip. Latches, sash locks or gate hooks should be used to provide positive closure. Attic hatches must not be permanently sealed.

A lightweight attic hatch may be cut from damaged insulated foam core doors. The door has an R-value around 7. Batt insulation may be attached to the back of the door panel to achieve desired R-value. The door panel is pre-finished, light-weight and requires no additional painting.

21233 Walk-up Stairway and Door

Careful consideration should be given as to how to establish a continuous thermal and air boundary around or over top of the attic stairway. If possible, install a hinged, insulated, and weatherstripped hatch door.



An open blow with cellulose in an attic

If attic is accessed by a stairwell and standard vertical door, blow dense-packed cellulose insulation into walls of stairwell leading to passage door of the unheated attic. Install threshold or door sweep, and weatherstrip door.

Dense-packed cellulose insulation should also be blown into the cavity beneath the stair treads and risers. Determine if blocking exists to stop insulation from filling

other areas by mistake when planning to insulate walls and stairway. Balloon framed walls and deep stair cavities may prevent blown insulation from being cost effective.

21234 Retractable Attic Stairway

An insulated box may be built and placed over the stairway. Alternately, a manufactured stair-and-hatchway cover may be purchased.

2124 Attic Insulation Assessment

Estimate effective R-value of existing insulation taking into account age and condition of insulation. Condition should include settling, uniformity of coverage and extent of attic bypasses.

Evaluate effectiveness of existing batt insulation (see Table 212-1). Voids or gaps between batts diminish their effectiveness. Batts should be in firm contact with ceiling surface.

Effective R-values for Batt Insulation*

Table 212-1

	“Good”	“Fair”	“Poor”
Measured Batt Thickness (inches)	Effective R-value (2.5 per inch)	Effective R-value (1.8 per inch)	Effective R-value (0.7 per inch)
0	0	0	0
1	3	2	1
2	5	4	1.5
3	8	5	2
4	10	7	3
5	13	9	3.5
6	15	11	4
7	18	13	5
8	20	14	5.5
9	23	16	6
10	25	18	7
11	28	20	8
12	30	22	8.5

1. Measure the insulation thickness.
2. Determine the condition of the installation using the following criteria:
 - ✓ Good – No gaps or other imperfections
 - ✓ Fair – Gaps over 2.5% of the insulated area. (This equals 3/8 inch space along a 14.5 inch batt.)
 - ✓ Poor – Gaps over 5% of the insulated area. (This equals 3/4 inch space along a 14.5 inch batt.)
3. Look up the effective R-value of the installed insulation using the condition and measured inches.

*Derived from ASHRAE document “Heat Transmission Coefficients for

Walls, Roofs, Ceilings, and Floors” 1996

R-value of new attic insulation should be based on the “effective” R-value of the existing insulation. If effective R-value of attic insulation is less than R15, attics should be insulated to the recommended R-values established by the state weatherization

program. For comparison purposes, The US Department of Energy recommends R49 attic insulation for new homes built in the Region V area heated with natural gas.

Follow state weatherization program guidelines for determining additional attic insulation when existing effective R-value is greater than 15.

It is recommended that blown insulation be used instead of batt insulation whenever possible because blown insulation forms a seamless blanket. Blowing attic insulation at the highest achievable density helps resist settling and reduce convection currents moving within the insulation.

2125 Unfinished Attic Insulation

21251 Blowing Insulation

OSHA-approved breather masks must be worn when blowing insulation.

Blown insulation is recommended for unfinished attic cavities. Insulation shall be installed to a uniform depth according to manufacturers' specifications for proper coverage (bags per square foot ratio) to attain the desired R-value at settled density.

Cellulose insulation from most manufacturers is available in at least two grades that are characterized by the fire retardant added to the insulation. The fire retardants are usually 1) a mix of ammonium sulfate and boric acid or 2) boric acid only (termed "borate only"). It's recommended that cellulose insulation be the "borate only" grade.



Do not blow loose-fill insulation tight against roof deck over top plates. Cellulose should not be specified where it may come in contact with exposed metal roofing.

Attic measuring sticks are required to be placed in the insulation showing insulation depth.

Ensure that intentional penetrations are free of insulation overblow and are not restricted.

Loose fill insulation installed around a furnace in the attic must have 12 inch clearance around all sides of the furnace and plenum.

Dense pack all attic cavities, such as slopes, window bays, flat roofs and attics if not accessible for other installation methods. Install blown cellulose to 3.25 to 3.75 lbs/ft³ or blown fiberglass to 1.6 lbs/ft³. Access these areas by drilling or removing

the fascia board and tube filling each cavity. Ventilation is not needed when dense packing flat roofs.

21252 Floored Attics

Flooring should be removed at bypass locations for proper air sealing before insulation is installed. Insulation should completely fill the floor cavity. Install blown cellulose to 3.25 to 3.75 lbs/ft³ or blown fiberglass to 1.6 lbs/ft³. Flooring boards that have been removed should be re-installed. With owner permission, flooring boards may be drilled and the cavity filled with blown insulation. Entry holes should be sealed with plastic or wood plugs.

If client is not using a floored attic, insulation may be blown over flooring with client's permission. Blowing insulation over the flooring may be done in addition to blowing the floor cavity – *not* in lieu of blowing the floor cavity.

21253 Batt Insulation

Batt insulation must be installed in such a manner to ensure proper fit between ceiling joists. There should be no voids or gaps between batts, between batts and ceiling joists or between batts and ceiling finish. Insulation must fill joist cavity and provide uniform and complete coverage. If insulation has vapor barrier backing, the vapor barrier shall be toward heated space. When insulation with vapor barrier is installed over existing insulation, the vapor barrier should be removed.

21254 Cathedral Ceilings

Inspect interior ceiling finishes for unsound/weak areas. Either repair damaged ceiling areas or do not insulate. Inspect ceiling for knob and tube wiring, thermal bypasses, open electrical boxes, blocking and recessed lighting fixtures.

Access rafter cavities in cathedral ceilings through soffit/fascia or interior ceilings.

Block top and bottom of open rafter cavities with fiberglass or other blocking material. Dense pack cavities with cellulose insulation installed to a density between 3.25 to 3.75 lbs/ft³. Blown fiberglass is not recommended as it does not restrict the movement of air through it.



Chimneys must be blocked to keep cellulose at least two inches away from the masonry

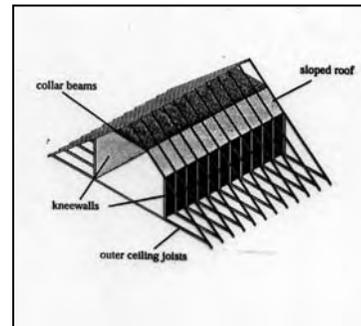
Properly plug interior access holes, seal and paint to match ceiling finish.

Ventilation is not needed when dense packing cathedral ceilings.

2126 Finished Attic- Insulation

The finished attic consists of five sections.

- Exterior finished attic walls (end walls of finished attic)
- Collar beams (above finished attic)
- Sloped ceiling (where wall/roof finish is installed directly to roof rafters)
- Knee walls (between finished attic and unconditioned attic space)
- Outer ceiling joists (between knee wall and top plate of exterior wall)



Finished attic sections

21261 Exterior Finished Attic Walls

Insulate exterior finished attic walls per section 213, “Sidewall insulation”.

21262 Collar Beams & Outer Ceiling Joists

Insulate collar beams and outer ceiling joists as described in section 2125, “Unfinished Attic - Insulation”.

21263 Sloped Ceiling

Sloped ceiling runs shall be tightly stuffed with fiberglass or some other stuffing material at either the top or the bottom of each run. Where possible, insulate sloped roof with dense pack cellulose installed to density of 3.25 to 3.75 lbs/ft³.

If the sloped areas have existing fiberglass insulation, the top and the bottom of each cavity may be sealed and the cavity insulated with dense pack cellulose.

21264 Knee Walls

- Open cavity knee wall - Batts
Insulate knee walls with maximum R-value as allowed by stud cavity depth. Extend batt insulation down to ceiling of conditioned space below. Ensure that joist cavity beneath knee wall has been air sealed with a solid material.

Insulation should fit snugly between the studs. Vapor barrier facing on batt insulation should be installed toward the conditioned space.

Batt insulation should be covered with an air barrier material to prevent convective looping within the insulation and to prevent fiberglass exposure. House wrap material, “belly patch” or ½ inch insulated foam sheathing may be used to cover the insulation.

- Open cavity knee wall - Dense pack

Close-in knee wall studs with house wrap material, “belly-patch” or ½ inch insulated foam sheathing tightly using plastic-ring head nails. Space nails no more than 3 inches apart. Secure material to top and bottom of knee wall to keep insulation in knee wall. If necessary, install additional horizontal or vertical strapping to secure material to studs prior to dense packing. Do not use polyethylene or similar vapor barrier material for knee wall enclosure.

Cut holes in knee wall material and insulate to a high density pack (3.25-3.75 lbs/ft³ for cellulose and 1.6 lbs/ft³ for fiberglass).

- Closed cavity knee wall
Insulate closed cavity knee walls per section 213, “Sidewall Insulation”.
- Knee wall within conditioned space
When the space behind the knee wall is considered part of the conditioned space, insulate rafter cavity with maximum R-value as allowed by rafter cavity depth. The attic floor cavity over the top plate must be air sealed and insulated to extend the thermal boundary from the sidewalls to the roof.

21265 Knee Wall Hatch

Access hatches to attics behind knee walls may be installed where none exist. New knee wall access should be located in an area agreeable with the client and conducive to the installation of the knee wall insulation.

The access should be properly framed, be as wide as the knee wall stud cavity and be 20 inches high. The access cover should be a durable, rigid material and securely attached with appropriate hardware. Access hatch should be weatherstripped and insulated with a minimum of R13 batt or R7 insulated foam board. Window casing may be used as interior trim around hatch opening. Joints in the casing should be caulked prior to painting.



Dense packing the back of a knee wall with cellulose

Existing knee wall access hatches should be weatherstripped and insulated with a minimum of R13 batt or R7 insulated foam board. A new access cover of a durable rigid material should be installed if necessary.

2127 Attic Venting

Attic venting was once thought to be the principle strategy for reducing attic moisture and condensation during the winter. Reducing the cooling load of the house during the summer and increasing the service life of shingles were thought to be additional benefits. However, research over the past few years indicates that attic ventilation has little to do with these issues.¹⁷

Controlling indoor humidity levels and sealing attic bypasses should be the primary means of controlling moisture in the attics. Other means, such as increased attic insulation and window shading, have a greater impact on reducing the cooling load of a home than attic ventilation. Shingle color and roof orientation have a far greater impact on shingle temperature than attic ventilation with lighter color shingles being more effective than darker shingles.

Installing or increasing attic ventilation may be part of an overall strategy for controlling attic air temperatures and should be considered an optional measure. The priorities should be on controlling indoor relative humidity issues, sealing attic bypasses and then attic ventilation. If attic vents are included as part of an overall attic air sealing/insulation strategy, the following guidelines should be met.

- Vent devices should not permit rain or snow to enter the attic.
- Ridge vents should not be installed on hip rafters.
- The structural integrity of a roof system should not be compromised for the sake of installing attic ventilation.
- Venting an attic does not make it acceptable to terminate bathroom, kitchen or dryer vents in an attic.
- If roof vents must be installed, try to do so on the least visible roof surface.

21271 Existing Vents

Ensure that existing vents are not blocked, crushed or otherwise obstructed. If the net free ventilation area of existing vents is not known, assume that it is half the area of the vent opening.

21272 Vent Ratios

Wherever possible, attic vents should be installed so there are equal amounts of low intake vents through soffit or eaves and higher exit vents on the roof. All separate attic spaces should be cross ventilated with one inlet and one outlet vent.

- 1 ft² of vent area for every 150 ft² of attic (1:150)
 - If no vapor barrier is present.
- 1 ft² of vent area for every 300 ft² of attic (1:300)

¹⁷ “Venting of Attic and Cathedral Ceilings” by William B. Rose and Anton TenWolde from the ASHRAE Journal, October 2002.

- If a vapor barrier is present.
- If a vapor barrier is not present and 50% of the required venting area is provided by vents located in the upper portion of the roof with the remainder of the required ventilation provided by eaves or soffit vents.
- If air sealing work has been completed at the attic floor.

Attic vents are not to be closed in the winter months. Clients should be instructed that vents are to remain open.

21273 Low/High Venting

Low (intake) vents should be placed at a minimum of 12 inches above the finished level of attic insulation. Eave chutes or baffles should be provided over top plates where soffit and other low vents could cause blowing of loose fill insulation. The eave chutes or baffles should deflect air above the surface of the insulation and prevent blockage of the vents by the insulation.

High (exhaust) vents should be installed as close to the roof peak as possible in conjunction with lower intake vents. If eave vents are not practical, other vents should be installed low on the roof. Consideration should be given to maximizing cross ventilation.

Vents should be installed in accordance with manufacturers' instructions and sealed with an appropriate sealant. Vents should be installed in a manner to prevent the entrance of snow, rain, insects and rodents.

21274 Soffit Vents

Use soffit vent products specifically designed for this purpose. Soffit vents should be installed with the louvers facing toward the house. Vents may be nailed or screwed to the soffit.

Open area between eave chutes or baffles and the top plate must be blocked with a material, such as rolled fiberglass or two-part foam, to prevent spillage of loose fill insulation into the soffit area and potential blockage of the soffit vents.

21275 Gable Vents

Gable vents should be installed either as high or low venting in the gable and positioned to allow for cross ventilation. Install gable end vents as high in the gable end as possible and above the level of the attic insulation. Existing gable vents should be boxed if insulation comes up to the bottom of the vent.

Framing members are not be cut or removed if gable vents are placed over them. Vent openings must be neatly cut. The vent must be installed with nails or screws. Framing must be provided for the vent if there is no sheathing behind the siding.

The perimeter of the vent must be properly caulked to prevent water entry. A gable vent used as an attic access must be attached by screws and easily removable.

If gable vents are prone to wind driven rain or snow entry, install interior or exterior baffles.

21276 Roof Vents

Roof vents should not be installed on a roof that is in poor condition.

Roof vents are not to be installed over rafters. Vent openings must be neatly cut with close tolerance to ensure a proper fit. High-mounted vents must be installed as high on the roof as practical. Vents should be tucked under shingles as much as possible and may be either fastened with shingle nails and tarred with roofing cement or nailed with neoprene-washed nails to ensure a leak-free installation. Surface-mounted roof vents are not allowed.

2128 Attic Insulation Certificate

Contractors installing blown-in insulation must permanently fasten to the roof side of the attic access (or other accessible location specified by the agency) a signed certificate that attests to the company name, date installed, insulation brand name, R-value added, square footage, thermal resistance chart, conformance to federal specifications, and the number of bags installed in the attic and sidewalls.