Illinois
Department of Commerce
& Economic Opportunity
OFFICE OF COMMUNITY ASSISTANCE

Illinois Home Weatherization Assistance Program - Field Standards Manual

July 2026

All improvements associated with the Illinois Home Weatherization Assistance Program shall be completed in a professional and skillful manner and shall be neat in appearance.

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100 – Diagnostic Standards

111 Blower Door

111-1 House Set-Up

Preparing the house for a blower door test involves putting the house in its heating condition with conditioned spaces open to the blower door. The house should be tested in the "as found" winter condition to determine its existing leakage rate.

Winter condition means that all windows and exterior doors are closed. "As found" means that holes found in the thermal boundary should not be sealed for the blower door test. Basement door shall be open if basement is within the thermal boundary of the home (see section 111-1-1, "Basements and Crawl Spaces").

- **Check work order for assessor comments regarding any unusual house set-up conditions.**
- **Note if pressurization test should be done rather than depressurization test (see section 111-2-1, "Existing Leakage Rate").**
- Confirm location of the thermal boundaries and house zones that are conditioned (see section 211, "Thermal Boundary").
- Deactivate all vented combustion appliances by turning off the heating appliance and setting the water heater to "pilot" or "vacation". Turning the thermostat down at least 10 degrees can also be used to turn the heating appliances off.
- Prevent ashes of wood/coal burning units from entering the living space by closing/sealing doors and dampers and/or by cleaning out ashes (Figure 111-1-1).

Figure 111-1-1: Ensure that ashes are not drawn into the home during the blower door test

- Inspect house for loose or missing hatchways, paneling, ceiling tiles or glazing panes. Secure any items that may become dislocated during the test.
- Remove one ceiling tile on suspended ceilings to relieve pressure (Figure 111-1-2).
- Open interior doors so that all indoor areas within the thermal boundary are connected to the blower door; closet doors may remain closed unless they are a walk-in closet and/or have a supply register.
- Do not seal intentional exhaust air openings, such as combustion appliance flues, dryer vents or exhaust fans.
- Temporarily seal intentional fresh air openings (air ducted from the outdoors to the furnace, for example).
- Do **not** temporarily seal large obvious leaks such as missing or broken glass (this represents the "as found" condition of the home).
- If window air-conditioning units are left in place over the heating season, conduct blower door test with the "as found condition". If occupants remove air-conditioning units over the heating season, temporarily air-seal around units for blower door test.

Figure 111-1-2: Remove a ceiling tile to relieve

111-1-1 Basements and Crawl Spaces

Basements may be used as living space. Furnaces and boilers and their respective distribution systems, water heaters and washers/dryers are often located in the basement. Heat from these items as well as heat from the space above helps condition basements during the winter. Therefore, basements are usually considered conditioned space and basement doors should be open during the blower door test unless of one the following conditions

are present (even if the basement door is generally closed during the winter):

- Access to the basement is through an exterior door such as bulkhead doors or through an unconditioned porch.

If you're not sure whether the basement door was open or closed during the assessment, call the assessor.

Crawl spaces are often included within the thermal boundary of the home. However, access hatches from the house to the crawl space should remain closed during the blower door test as the crawl space is non-occupiable space.

111-2 Blower Door Test

The blower door (Figures 111-2-1) measures the total leakage rate of a home, indicates the potential for air leakage reduction in a home, assists in finding air leakage locations and verifies that air sealing was successful. Four leakage rate numbers are associated with the blower door test:

- Existing Leakage Rate,
- Target Leakage Rate,
- Intermediate Leakage Rate, and
- Contractor Final Rate.

Figure 111-2-1: Blower door set-up

Mobile homes should be treated similarly to single-family homes when determining target leakage rate numbers.

Manometers must be calibrated per manufacturer's recommendations. Generally, a label affixed to the manometer indicates when the manometer is to be calibrated. Figure 111-2-2 shows the hose connections for doing a blower door test for the three commonly used manometers.



Figure 111-2-2: Hose connections for the DG1000, DG700 and

111-2-1 Existing Leakage Rate

Conduct a blower door depressurization test to determine the existing CFM50 leakage rate of the home. Record the existing CFM50 leakage rate. The average existing leakage rate in Illinois' homes prior to weatherization is about 3600 CFM.

Depressurization Test

A depressurization test is required (unless it is determined that a pressurization test is necessary – see next section) as it is the standard test in the low-income weatherization program. If there are concerns about doing a depressurization test, perform a pressurization test or gradually depressurize the house toward -50 Pa while checking the condition of the suspect areas. If, during this gradual depressurization, it is believed that further depressurization is likely to cause a problem, depressurize as much as possible and use the corrected CFM50[1].

Pressurization Test

A pressurization test should be done, rather than a depressurization test, if one of the following conditions is present in the home:

- Presence of suspected asbestos containing material (ACM) such as vermiculite attic insulation which could be drawn into the home during a depressurization test (See section 501, "Vermiculite".)
- Animal or bird feces, or mold, is found in the attic that may be a health hazard,

[1] Can be done automatically with the DG700, DG1000 or DM32 manometer; see job aid for assistance

- Hole in top floor ceiling that may result in insulation being pulled into the home,
- Interior wall or ceiling finishes might be pulled down by a depressurization test,
- Open sump in basement,
- Open sewer line in the home, or
- Harmful pollutants could be introduced into the home by the operation of the blower door.

Mold on walls is not a reason to pressurize. A depressurization test is acceptable in such cases.

Can't Reach 50 Pascals
If the blower door cannot achieve -50 Pa house pressure, re-inspect the home to assure that all windows and doors are closed. If -50 Pa cannot be achieved, the CFM50 of the house will still be shown in the B channel display when the manometer is properly set up (Figure 111-2-1-1).

Figure 111-2-1-1: CFM50 is displayed when 50Pa cannot be achieved in a home

111-2-2 Target CFM50 Rates
Target CFM50 levels based on a range of existing leakage rates are shown in Table 100-1. Target CFM50 levels relate existing CFM50 leakage rates to expected post-weatherization leakage rates. The premise is that homes with high leakage rates have a potential for larger cost-effective leakage reductions than tighter dwellings.

- Air sealing work should continue when the target has been achieved, and additional air sealing opportunities are present.
- The most cost-effective air sealing involves addressing the largest leakage paths first and sealing leaks in the top and bottom parts of the home.

- Confirm effectiveness of air sealing strategies by performing intermediate blower door tests.
-

Table 100-1 Target CFM50 Rates

Existing CFM50	Target CFM50 Rates
0 to 1250	99% of existing CFM50
1251 to 1560	90% of existing CFM50
1561 to 2750	72% of existing CFM50
2751 to 4250	64% of existing CFM50
4251 to 5500	54% of existing CFM50
5501 to 7500	50% of existing CFM50
> 7500	45% of existing CFM50

111-2-3 Intermediate Blower Door Test

Blower door guided air sealing is recommended. Contractors should take "intermediate readings" while doing air sealing work. These readings provide immediate feedback on effectiveness of air sealing work.

111-2-4 Contractor Blower Door Requirements

- **Contractors are required to do an initial blower door test before beginning work to confirm the assessor's existing leakage rate and target CFM50 rate.**
    - If the contractor's existing leakage rate is off by more than10% of the assessor's recorded leakage rate, the contractor should call the assessor to ensure that house set-up is the same as it was during the assessment. If necessary, the assessor may re-calculate the target CFM50 rate.

- Contractors should ensure the effectiveness of air sealing work.
    - Air sealing work should be validated using smoke with the house under depressurization or pressurization.

- Zone pressure measurements should be taken and compared to the assessor's zone pressure numbers (see section 113, "Zone Pressures").

- Contractors must submit their final blower door reading to the WX agency.
- Architectural contractors and crews are required to conduct a spillage test-out every day following completion of work (see section 117, "Spillage Test-Out"). This test is only required for Category I appliances within the pressure boundary.

111-3 Deferred Air Sealing

Air sealing should be done in all homes; however, air sealing work may have been deferred by the WX agency until the following conditions are corrected.

- Carbon monoxide levels exceed suggested action levels (see section 312-3, "Carbon Monoxide (CO) Testing")[2],
- Presence of unvented space heaters (note that no weatherization may occur in the home until unvented space heaters are removed; see Section 317, "Unvented Space Heaters"),
- Evidence of serious mold issues (an area of mold greater than 10 ft^2)[2],
- Appliance fails spillage test-out (see section 117, "Spillage Test-Out"), or
- Presence of vermiculite attic insulation which would preclude attic bypass air sealing. Air sealing may proceed in other areas of the home. See section 501, "Vermiculite".
    - If vermiculite has been tested and asbestos is not present, air sealing in the attic may be done.

111-4 After Completing Blower Door Test

The following items must be checked after conducting a blower door test.

[2] Reason for deferral of weatherization

- Inspect all pilot lights of combustion appliances to ensure that blower door testing did not extinguish them; relight pilot lights that have extinguished
- Return heating appliances and water heaters to their original settings.

112 ASHRAE 62.2-2016

ASHRAE 62.2-2016, *"Ventilation and Acceptable Indoor Air Quality in Residential Buildings"*, defines minimum requirements for mechanical ventilation intended to provide acceptable indoor air quality in all residential buildings.

The type of ventilation system and required ventilation rate will be specified by the Weatherization Agency for each house or unit. This information will be included on the work order. Ventilation systems and installation standards are found in Section 505, "ASHRAE 62.2".

All homes and units weatherized must meet the ventilation airflow requirements of ASHRAE 62.2-2016. All architectural and mechanical contractors should familiarize themselves with these requirements.

ASHRAE 62.2 does not prescribe the location for installing required ventilation. When exhaust ventilation is used to comply with ASHRAE 62.2 requirements, IHWAP policy is to place the ventilation in centrally-located kitchens and bathrooms whenever possible. Basements are not to be used unless there are sleeping accommodations in the basement, unless given approval by your State Weatherization Specialist. Bathrooms in remote locations, especially when multiple doors can be closed between the bathroom and the rest of the home (e.g. a primary bathroom within a primary bedroom suite), are also to be avoided without the approval of your state weatherization specialist.

113 Zone Pressures

The blower door can be an effective tool at finding direct leaks by depressurizing the house and looking or feeling for airflow through leaks. However, leaking air often takes a path through two surfaces that have a space, or zone, between them. These leakage sites may be difficult to find because they are in unconditioned spaces of a house. Once found, these leaks may be the largest and easiest leaks to seal.

A "zone" is a space that separates a heated space from the outdoors. Typical zones include attics, knee wall spaces, crawl spaces and enclosed garages. Due to their common connections to outside and attics, basements are also frequently zones. The inner boundaries of these zones are building components such as walls, ceilings or floors that separate these zones from the conditioned space. The outer boundaries of these zones are the walls, roofs and foundation walls that separate a zone from the outdoors.

Zone-to-outside pressure readings provide information on the relative leakiness between the house and zones and are described in section 113-1, "Zone-to-Outside Readings". Basic zone pressure testing procedures are described in section 113-2-1. The area of the "hole" between the house and the zone can then be determined by "adding a hole". That procedure is described section 113-2-2, "Add-a-Hole" Method. The "Add-a-Hole" Method should be done whenever feasible.

113-1 Zone-to-Outside Readings

A pressure difference from the zone to the outside is measured with reference to outside, with the blower door depressurizing the house to -50 Pa. The pressure measured between the zone and the outside can indicate the relative leakiness of the zone.

- Zone-to-outside readings of 0 to -25 Pa indicate that the zone is more connected to "outside".
- Zone-to-outside readings of -25 Pa to -50 Pa indicate that the zone is more connected to inside".

Zone pressure readings unto themselves may be misleading. For example, an attic-to-outside reading of -15 Pa may seem to indicate significant bypasses. However, when tested with the "Add-a-Hole" method, the size of the hole may be small and not worth the effort to air-seal.

113-2 Zone Pressure Testing Procedures

Utilize the following procedures for measuring zone pressures (section 113-2-1) and determining leakage areas with the "Add-a-Hole" method (section 113-2-2) in attics, knee wall spaces, crawl spaces and attached or tuck-under garages.

113-2-1 Measuring Zone Pressures

- Identify zones to be measured.
- Set-up blower door for house leakage test.
- Set-up a hose to measure pressure in a zone. Make sure that end of hose extends beyond insulation, flooring or other obstructions in the zone.
- Close opening (door, access hatch) between zone and conditioned space, taking care not to pinch hose.
- Depressurize house to -50 Pa. (Pressurization tests can also be done when needed).
- Record CFM50 of house ($CFM50_1$).
- Record actual house pressure, even if -50 Pa could not be reached.
- Connect hose from zone to "input" tap on manometer. Connect hose from the outside to "reference" tap on the same channel as the hose from the zone. Be sure to disengage cruise control if being used on the manometer.
- Record pressure of zone with reference to the outside - Z/O_1 (Figures 113-2-1-1 & 2).
- Compare readings to those shown in Table 100-3.

- Continue with the "Add-a-Hole" Method to determine cumulative hole size. (Refer to Zone Pressure job aid and Add-A-Hole Method job aid as needed)

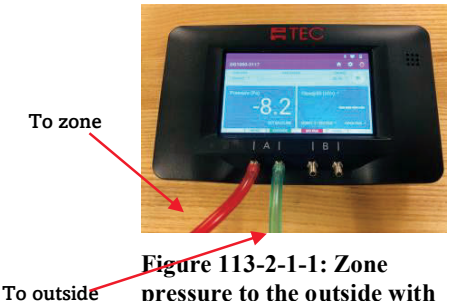


Figure 113-2-1-1: Zone pressure to the outside with

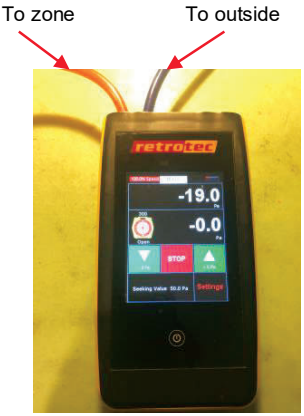


Figure 113-2-1-2: Zone pressure to the outside with DM32

Table 100-3 – Zone Pressure Readings

Zone	Thermal Boundary Location	Zone Pressure Reading
Attic	Top floor ceiling and attic space	0 to -5 Pa wrt outside
Knee wall space	Knee wall and knee wall cavity, or Knee wall space and roof	0 to -5 Pa wrt outside - 45 to -50 Pa wrt outside
Crawl Space	Foundation wall and crawl space, or Floor between house and crawl space	- 45 to -50 Pa wrt outside 0 to -5 Pa wrt outside
Attached or tuck-under garage	Between house and garage	0 to -5 Pa wrt outside
Basement	Basement foundation walls	-45 to -50 Pa wrt outside

113-2-2 “Add-a-Hole” Method

The “Add-a Hole” Method should be used whenever feasible to estimate the total size of all the holes and bypasses in a zone being measured. This will provide guidance towards existing opportunities for air sealing in the zone and requires the use of the IWx app or the IHWAP Diagnostics app.

- Remove the zone pressure hose from the manometer.
- Open a door, access hatch, or other opening between zone and conditioned space, making sure that pressure hose remains in the zone.
- Readjust the blower door to achieve -50 Pa, or as close as possible.
- Record CFM50 of house ($CFM50_2$).
- Record actual house pressure, even if -50 Pa could not be reached ($Phouse_2$).
- Connect hose from zone to “input” tap on manometer. Connect hose from the outside to “reference” tap on the same channel as the hose from the zone. Be sure to disengage cruise control if being used on the manometer.
- Record pressure of zone with reference to the outside - Z/O_2.

113-3 Zone Pressure Standards

Zone pressure readings following weatherization work are shown in Table 100-3. **If cumulative hole size is less than 20 in^2 (200 CFM50) as determined by the “add-a-hole” method, no air sealing is required regardless of zone pressure reading.**

114 Pressure-Pan Duct Test

The pressure-pan test is a duct leakage diagnostic tool that is used with the blower door and manometer to identify duct leakage to outside the thermal boundary of the home.

- Pressure pan testing is not required if the ductwork is being brought into the thermal boundary (ducts in a vented crawl space where the thermal boundary will become the foundation walls, for example).

- Pressure-pan testing is not required on ducts located in conditioned spaces.

Figure 114-1: Pressure pan test

A gasketed pan is placed over each register or grille with the air handler fan off and the blower door depressurizing the house to -50 Pa[3]. If the pan does not fit, cut mask tape may be used with the pressure hose penetrating through the tape. A pressure measurement between the duct and the room provides an indication of whether duct leakage to the outdoors exists (Figure 114-1).

Note that you must clear the baseline used for the blower door reading before taking pressure-pan readings. There is no need to use or establish a new baseline as the pressure difference between the ducts and conditioned space is simply being measured.

Pressure-pan testing is required when ducts are found in:

- Unconditioned spaces (some examples include attics, behind knee walls, tuck-under garages, crawl space where the floor is the thermal boundary), or
- Ducts located in conditioned space only when a spillage, duct pressure imbalance or indoor air quality problem has been identified such as:
    - failed spillage test (see section 312-2, “Spillage Test”),

[3] If the house is so leaky that it cannot be depressurized to -50 Pa, pressure pan readings will not be accurate. It is first desirable to tighten the house so that -50 Pa can be achieved so that pressure pan measurements can be taken. Note that significant leakage may be occurring through the duct system, though. Using a smoke pencil, look for air coming out of the registers. Look for and seal the leaks in the duct system if found to be leaking. Remember that sealing ducts outside the thermal boundary can help one achieve the target CFM50 rate.

- failed room-to-room pressure test (see section 115, "Room to Room Pressure Test") or other duct imbalance problem, or
- elevated moisture levels in the home associated with wet basements or crawl spaces.

- Pressure pan tests should always be conducted on mobile homes when the ducts are located in the floor cavity.

114-1 Pressure-Pan Procedures

- Install blower door and set-up house for winter conditions. Open all interior doors (see section 1111, "House Set-Up").
- **CLEAR BASELINE.**
- Turn furnace off. And ensure that the air handler fan is off.
- Temporarily seal any outside fresh-air intakes to the duct system.
- Close door to basement if testing ducts in basements. If possible, open a basement window or basement door to the outside.
- Connect a hose between the pressure-pan and the input tap on the manometer. Leave the reference tap open.
- With the blower door at -50 Pa, place the pressure-pan completely over a grille or register to form a tight seal. Record the reading. **Note that only one register is sealed at a time**.
- If a grille is too large or a supply register is difficult to access (under a kitchen cabinet, for example) or a pressure pan is not available, seal the grille or register with duct-mask tape (Figure

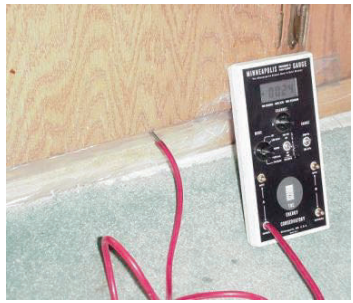


Figure 114-1-1: Toe-kick sealed with duct mask tape; pressure pan reading of 24 Pa!

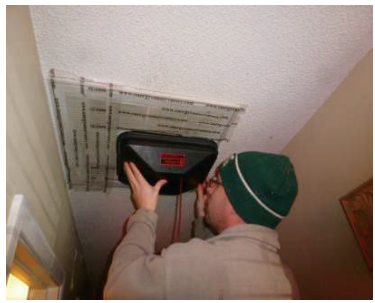


Figure 114-1-2: Duct partially covered with duct mask tape.

114-1-1). Grille can also be partially sealed with duct-mask tape and used with the pressure pan (Figure 114-1-2). Insert a pressure probe through the duct-mask tape and record reading. Remove tape following reading.

Note that no air should be coming out of registers when the blower door is operating. If air is felt coming out of a register, check to ensure that air handler is not operating. Otherwise, it's a duct leak (Figure 114-1-3).

Figure 114-1-3: Sometimes duct leakage is obvious before you use the pressure pan; air coming

Pressure pan readings greater than 3.0 Pa may indicate a leak between the duct boot and subfloor/wall/ceiling rather than a breach in the duct system. Remove registers on ducts with elevated readings and inspect the boot connection. Seal boots and re-test with the pressure-pan (see section 315-3-2, "Duct Sealing Materials").

114-2 Pressure-Pan Standards

- No more than half of the pressure-pan readings shall be higher than 3.0 Pa (Figure 114-2-1) and
- No readings shall be greater than 8.0 Pa.

Figure 114-2-1: Tight duct measuring 1.1 Pa

115 Room-to-Room Pressure Test

This is not a required test but can assist in solving spillage, comfort and indoor air quality problems. The test can determine if an imbalance between the supply and return ductwork exists, especially in homes with central return systems.

An imbalance between the supply and return sides of the distribution can be caused by duct leakage to the outside, restricted/inadequate returns and/or the restriction of supply flow back to the main living spaces of the house. This test measures pressure differences between the main body of the house and each room, including the combustion appliance zone (or basement).

115-1 Room-to-Room Pressure Procedures

- This test is conducted with the blower door turned off and sealed.
- Set-up house for winter conditions. Close all windows and exterior doors. Turn off all exhaust fans.
- Ensure that registers are not covered by furniture and other objects.
- Close all interior doors, including door to basement.
- Turn on air handler.
- Place hose from “input” tap on the manometer under the door to a room. Leave “reference” tap open to main body of house.
- Read and record measurement for each room.

115-2 Room-to-Room Pressure Standards

Pressure differences greater than +3.0 Pa or more negative than -3.0 Pa may (Figure 115-2-1). cause issues as mentioned above.

Figure 115-2-1: Room to room pressure is 31.6 Pa!

115-3 Interpreting Room-to-Room Pressures

Pressure relief may be required when pressures are more than + or -3.0 Pa between a room and the main body of the house with the air handler operating.

Figure 115-3-1: Jumper duct installed in attic connecting bedroom to hallwa (Courtesy Southface Institute)

To estimate the amount of pressure relief needed, slowly open door until the pressure difference drops between +3.0 Pa and -3.0 Pa. Estimate area of open door. This is the area required to provide pressure relief. Pressure relief may include undercutting the door, installing transfer grilles or installing jumper ducts (Figure 115-3-1).

116 Exhaust Fan Flow Meter Test

The exhaust fan flow meter is used to measure the air flow through bathroom exhaust fans. The flow meter is used with the manometer (Figure 116-1). This test must be done to confirm flow rates if exhaust fans are used to meet ASHRAE 62.2.

Figure 116-1: Exhaust fan flow meter being used to measure bathroom exhaust fan flow

116-1 Exhaust Fan Flow Meter Procedures

Air flow though the flow meter is measured in CFM with the manometer. The measured air flow can be used in the following manner.

- Determine flow rates of existing bathroom fans. Measured flow rates can be compared to rated flow rate of fans to determine the effectiveness of the fans.

- Adjust flow rate on variable speed fans to meet the required ASHRAE ventilation rate.

Refer to the *Exhaust Fan Flow Meter* job aid for setting up the manometer for using the flow meter.

117 Spillage Test-Out

Architectural contractors and crews are required to conduct a spillage test-out every day following completion of work. This test is to ensure that architectural work done that day has not adversely affected Category I appliance venting. This test is only required for Category I appliances.

It is highly recommended that contractors conduct this test prior to beginning weatherization work in homes that measure 2500 CFM or less to confirm that a spillage problem doesn't currently exist.

Ambient CO levels should be monitored while checking for spillage. If ambient CO levels equal or exceed 9 ppm, see section 502-2, "Indoor Ambient CO Action Levels", for additional guidance.

1. Close all windows and exterior doors.
2. Close fireplace damper.
3. Interior doors
   a. Close all interior doors, including door to combustion appliance zone (CAZ)[4].
   b. Open doors to rooms:
      i. with exhaust fans, such as bathrooms and kitchens
      ii. with ducted returns.
4. Close or seal supply air ducts in the CAZ. Leave return registers in the CAZ open.
5. Exhaust
   a. Turn on clothes dryer.

[4] CAZ is the space in which the Category I appliance is located.

b. Turn on all exhaust fans, such as bathroom and kitchen exhaust fans, such that they operate at maximum speed.
c. Do not turn on whole house fans.

6. Turn on furnace air handler.
7. Spillage
   a. Turn-on Category I appliance.
   b. Test for spillage at the draft diverter or draft hood with a mirror or smoke pencil.
8. Time limits[5] –

a. *Category I Water Heaters* -
Spillage must cease (water heater begins drafting) within two minutes. If water heater begins drafting within two minutes, the water heater passes the test (Figure 117-1).

b. Category I Furnaces - Warm Vent (when furnace thermostat is <u>on</u> heat and/or it is common-vented with a water heater) –
Spillage must cease (furnace begins drafting) within two minutes. If furnace begins drafting within two minutes, the furnace passes the test.

Figure 117-1: Conducting a spillage test with a smoke pencil

c. Category I Furnaces - Cold Vent (when furnace thermostat is <u>not on</u> heat AND the furnace is NOT common-vented with a water heater) –
Spillage must cease (furnace begins drafting) within five minutes. If furnace begins drafting within five minutes, the furnace passes the test.

If appliance fails spillage test (Figure 117-2) –
- Turn-off appliance
- Check personal CO monitor

[5] ANSI/BPI-1200-S-2017, "Standard Practice for Basic Analysis of Buildings", sections 7.9.2 and 7.9.3

- Open window in CAZ if possible
- Re-test if CO is below allowable limits
- If appliance passes, spillage was caused by depressurization
- If appliance fails, check for flue or chimney for blockage. If blockage is found and removed, repeat spillage test. Also see section 312-4, “Solutions to Combustion Safety Testing Failures”.

Figure 117-2: Failed spillage test

- Any appliance that fails spillage test-out may not be left in that condition.

200 – Architectural Standards

The architectural standards include insulation and air sealing measures. Insulation retrofits are designed to reduce heat loss by conduction. Air sealing measures are designed to reduce infiltration heat loss. It is important that both conduction and infiltration measures work together. If insulation is added to an attic but bypass air sealing is not done, the effectiveness of the insulation is greatly diminished. It is critical that insulation and air sealing be done in the same building plane if the thermal boundary is to be effective.

All material used must be in alignment with 10 CFR Part 440 Appendix A - Standards for Weatherization Materials.[1]

201 General Insulation Requirements

201-1 Flame Spread Index/Smoke Development Index
Insulation used in homes shall meet the Flame Spread and Smoke Development numbers shown in Table 201-1-1[2].

Table 201-1-1 Flame Spread and Smoke Development Indices*

	Flame Spread Index	Smoke Development Index
Batts	< 25	< 450
Blown	< 25	< 450
Foam Board	< 75	< 450
Spray Foam	< 75	< 450

*Foam insulations must be protected by ignition or thermal barriers[3]

[1] Appendix A to Part 440—Standards for Weatherization Materials
[2] Standard Work Specifications (SWS), National Renewable Energy Laboratory (NREL)
[3] SPFA-126, Section 202

201-2 Contractor Requirements

Contractors shall meet the onsite documentation as noted below for attics, cathedral ceilings, finished attics, sidewalls, foundations, floors and box sills. Note special requirements for box sill when spray foam is used.

Loose Fill & Dense Pack - Post a dated receipt signed by the installer that minimally includes installed insulation type, coverage area, installed thickness, minimum settled thickness, installed R-value and number of bags installed.

Batts, Foam Board & Spray Foam - Post a dated receipt signed by the installer that minimally include installed insulation type, coverage area, installed thickness and installed R-value.

Spray Foam in Box Sills[4] - Post a dated receipt signed by the installer that minimally includes installed insulation type, coverage area, installed thickness, installed R-value, manufacturer product name, manufacturer supplied material density and flame spread and smoke development index as tested per ASTME E84 or UL 723.

202 Ignition and Thermal Barriers

Ignition and thermal barrier requirements for insulation are dependent upon the location in the home where the insulation is installed. Specific requirements are listed by building section and insulation type. For addition information, refer to "SPFA-126, *"Thermal Barriers and Ignition Barriers for the Spray Polyurethane Foam Industry"* and the Standards Work Specifications (SWS).

[4] SWS 4.0401.1g, "Insulation – Onsite Documentation"

211 Thermal Boundary

The thermal boundary separates conditioned space from unconditioned space (Figure 211-1). Typically, the thermal boundary in a house consists of the exterior walls, top floor ceiling and foundation walls.

Figure 211-1: Diagram of Thermal Boundary

The thermal boundary is defined by the placement of insulation. The building component that separates the conditioned space from the outdoors or unconditioned space is the primary pressure boundary. To maximize the effectiveness of the thermal boundary, the pressure boundary must be aligned with it. That is, the pressure boundary must be part of the thermal boundary. If the insulation and air barrier are not aligned; that is, located in different building components, air can pass around or through the thermal boundary, making the insulation less effective.

Basement walls are generally part of the home's thermal boundary (see section 111-1-1, "Basements"). As such, the basement ceiling is not insulated nor are bypasses in the basement ceiling air sealed for energy savings. If it is determined that the basement walls are not part of the thermal boundary, the basement ceiling shall be insulated and air sealed. Ceilings in basements with the following characteristics may be considered the thermal boundary.

- Space heating and water heating appliances are not located in the basement,
- The occupants do not use the basement on a regular basis; for example, access to the basement is through an exterior door, bulkhead door, hatch, or
- Basement moisture problems that weatherization work cannot solve.

The work order will define the thermal boundary of the home as determined by the assessor. In some cases, there is no right or wrong answer, only implications to the assessor's decision. How does the home owner use the space (is it a living space even though it was not originally intended to be)? Does the budget or SIR priority permit for the ideal thermal boundary or does a concession need to be made (the assessor would like to insulate the floor above the crawl, water lines and duct work but can only afford to insulate the walls and install a ground cover)?

Do we want to expand the heated area of the home (insulating the rafter cavity rather than insulating and air sealing the knee walls and outer ceiling joists, for example)? What are the costs to establish the thermal boundary (insulation, air sealing, extending the duct work, for example)? These and other questions must be addressed by the assessor in defining the thermal boundary for some room additions, crawl spaces, enclosed porches, attics and knee wall cavities. Cost effectiveness and achieving the highest R-value should be considered when making judgement calls on the thermal boundary.

The work order will reflect these decisions. Contractors should contact the assessor to further discuss the thermal boundary definition if there are questions. Under no circumstances shall the contractor change the thermal boundary location without first discussing the implications with the assessor.

For additional information regarding the importance of identifying the thermal boundary correctly, see section 300 -"Thermal Boundary", in the IHWAP Assessment Manual.

212 Reducing Air Leakage

Air leakage reduction has always been one of weatherization's most important functions. Measures in the early days of Weatherization were limited to storm windows, storm doors,

weatherstripping and caulking – all with the intention of reducing air leakage. But these measures were not always highly successful.

Later came the blower door and advanced air sealing, again with the intent of reducing air leakage. Air sealing was much more successful, but now it was possible to make a home too tight. Air sealing had to be balanced against making a home too tight and creating indoor air quality problems.

Illinois has adopted ASHRAE 62.2, *"Ventilation and Acceptable Indoor Air Quality in Residential Buildings"*, as required by the US Department of Energy. This Standard requires the installation of mechanical ventilation systems in most homes. Homes can be made much tighter (as tight as you can get them) increasing energy savings without creating indoor air quality problems.

Objectives of air leakage reduction are to:

- Save energy by cutting air leakage,
- Maximize insulation's thermal resistance by reducing air movement through it,
- Avoid moisture migration into building cavities, and
- Increase comfort.

Combustion appliances must still vent properly, especially now that homes can be much tighter.

212-1 Testing

Architectural contractors are required to conduct the following tests.

- Check air sealing work with smoke puffers,
- Conduct intermediate blower door readings,
- Conduct and report their final blower door readings to the agency, and
- Conduct Spillage Test-Out procedure

Air sealing work must be tested with the blower door operating and smoke test verified that air sealing work is effective.

Check for leaks in the attic with a smoke puffer while the blower door is depressurizing the home (Figure 212-1-1).
Air will be drawn down into the home through bypasses. Seal bypasses and check work with the smoke puffer. If air is still being drawn into the home, additional air sealing is required. If the smoke does nothing, the bypass has been effectively sealed. Be sure attic hatch is closed to increase pressure difference between the attic and house.

Figure 212-1-1: Smoke being drawn down an open stud cavity indicating leakage to the inside

Bypasses can be sealed while the home is being depressurized. Spray foams (both 1- and 2-part) will be drawn into the joint to help seal it.

Alternately, turn the blower door around to pressurize the house (older fans have a direction switch that can be used to reverse the direction of air flow). Air will move up into the attic through bypasses. Be sure the attic hatch or door is closed to increase pressure in the home. Pressure testing the house may assist in finding air leakage locations if air sealing efforts have not been effective, particularly in knee wall cavities, crawl space floors and attached or tuck-under garages. Air sealing should not be done while pressurizing the home as spray foam may be blown back at the installer.

It is highly recommended that contractors take intermediate blower door readings (see section 111-2-3, “Intermediate Leakage Rate

Test") to measure effectiveness of their air sealing work and to assist in finding additional air sealing opportunities.

Contractors are required to take a final blower door reading when air sealing work is complete. The contractor final blower door reading must be submitted to the agency. See section 111-2-4, "Contractor Blower Door Requirements", for additional requirements.

It is required that contractors conduct Spillage Test-Out following work each day to ensure that spillage will not occur in the combustion appliance zones as a result of tightening the home (see section 117, "Spillage Test-Out").

212-2 Sealing Bypasses[5]

Bypasses are holes and gaps in the thermal boundary that connect conditioned space with unconditioned space. The effort worth expending to seal a bypass depends primarily on its size and location. Bypasses will be found between the conditioned space and attic, conditioned space and crawl space and conditioned space and attached garages.

Seal 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, an open chaseway in a plumbing wall that is well-sealed from the house but is open to the attic would still be an insulation bypass without leaking air between the house and the attic, likely leading to convective looping. Even though the house air leakage may not be reduced, the attic insulation performance will improve after this attic bypass is sealed.

[5] SWS 3.0101.1, "Air Sealing Holes"

It is always preferable to use strong air-barrier materials like rigid foam board, plywood or gypsum board to seal bypasses. These materials should be mechanically attached. Strong materials with strong bonds are best practice because air barriers must be able to resist strong pressures. When bypasses are not easily accessible, blow dense-packed cellulose or fiberglass insulation into surrounding cavities so that the cellulose will resist airflow and clog cracks between building materials (see sections 214-2, “Dense-Packed Wall Insulation - Cellulose” or 214-3, “Dense-Packed Wall Insulation – Fiberglass”).

Figure 212-2-1: Sealing joist cavity under knee wall with foam board and 2-part spray foam

All bypasses are to be sealed prior to insulating except where dense-packed insulation is also being used to seal bypasses.

- **Joist spaces under knee walls in finished attic areas**[6]:
- Connect knee wall air barriers on two floors by creating a rigid seal under the knee wall in one of two ways.
  - Install minimum 1-inch-thick rigid foam board insulation blocks between ceiling joists. The perimeter of the foam blocks should be sealed with two-part foam (Figure 212-2-1), or
  - Tightly fill garbage bags or empty cellulose bags with cellulose or fiberglass. Stuff between ceiling joists under knee wall and seal perimeter with two-part foam.

Figure 212-2-2: Soffit sealed with foam board and 2-part spray foam

[6] SWS 3.0102.11e, “Install Air Barrier”

- Kitchen or bathroom interior soffits: Seal the top of the soffit with plywood, gypsum board or rigid foam board insulation: mechanically fasten and seal to ceiling joists and soffit framing with two-part spray foam (Figure 212-2-2)[7].
- **Two-level attics in split-level houses:**
  - Seal the wall cavity with a rigid material mechanically fastened to studs and wall material, or
  - Block stud cavity with scrap batt insulation and cover with 2-part spray foam (Figures 212-2-3 & 212-2-4), or
  - Tightly fill garbage bags or empty cellulose bags with cellulose or fiberglass batts. Stuff in wall cavity and seal perimeter with two-part spray foam (Figure 212-2-5) if still leaking.
- **Tops and bottoms of balloon framed interior partition wall cavities, missing top plates**:
  - Tightly fill garbage bags or empty cellulose bags with cellulose or fiberglass. Stuff in wall cavity and seal perimeter with two-part spray foam (Figure 212-2-5), or

Figure 212-2-3: Stud cavity sealed with 2-part spray foam

Figure 212-2-4: Study cavity blocked with batt insulation and sealed with 2-part spray foam

Figure 212-2-5: Balloon framed stud cavity sealed with fiberglass batts stuffed in cellulose insulation bags

[7] SWS 3.0102.9, "Sealing Dropped Soffits/Bulkheads"

- Seal with rigid barrier, like ¼ inch plywood, gypsum board or rigid foam board insulation and caulk or foam to surrounding materials, or
- Block stud cavity with scrap batt insulation and cover with 2-part spray foam.

Figure 212-2-6: Fur cavity sealed with 2-part spray foam

- **Fur cavity in masonry buildings**: Seal cavity with one or two-part foam around perimeter of attic/roof cavity (Figure 212-2-6).
- **Chimney passing through attic floor**[8]: Seal chimney and fireplace bypasses with sheet metal (minimum 26 gauge thickness) and seal to chimney or flue and ceiling structure with high temperature RED caulk or chimney cement. Must be RED for ease of inspection. (Figure 212-2-7) A "fire block" spray foam is not permitted for this application. This requirement does not apply to chimneys that:
  - Are no longer used and have been permanently sealed with concrete both at the vent connector to the chimney and at the top of the chimney, or

Figure 212-2-7: Seal chimney bypass with sheet metal and high temperature RED sealant

Figure 212-2-8: Cut-off chimney in attic

[8] SWS 3.0102.2, "Sealing High-Temperature Devices"

- Chimneys that have been cut-off in the attic (no longer extend through the roof) and do not contain a furnace or water heater vent that is vented through the roof (Figure 212-2-8).

- **Soil stacks, plumbing vents, open plumbing walls**: Seal joints with two-part foam or caulk. If joint is too large, create a backing by stuffing fiberglass batts or place foam board and then spray foam to seal the top. (Figure 212-2-9).
- **Housings of existing exhaust fans and recessed lights**[9]: Caulk joints where housing meets the ceiling (see section 213-1, "Attic Insulation Safety" for boxing and air sealing around recessed lights and exhaust fan housings[10]).

Figure 212-2-9: Plumbing wall cavity sealed with foam board and 2-part spray foam

- **Duct boots and registers**: Caulk, foam or duct mastic to seal joint between duct boot or registers and ceiling, wall, or floor finish if ducts are in attic, crawl space or attached or tuck-under garage.
- **Wiring and conduit penetrations**: Seal joint with caulk or foam.
- **Duct chases:** If chase opening is large, seal with rigid barrier such as plywood, gypsum board or rigid foam board and seal to ducts and ceiling materials (Figure 212-2-10). Smaller

Figure 212-2-10: Duct chase sealed with foam board and 2-part spray foam

[9] SWS 3.0102.1, "Sealing Non-Insulation Contact (IC) Recessed Light"
[10] Many new bathroom exhaust fans can be covered with insulation and do not require shielding to keep insulation away from them. Only bathroom exhaust fans that can be covered by insulation can be installed in the Weatherization Program (see section 505, "ASHRAE 62.2").

openings may be foamed or stuffed and caulked**.**

- **Joists between floors**: Air seal perimeter of building at bandjoist areas with dense-pack cellulose or fiberglass.
- **Bathtubs and shower stalls**: When a bathtub or shower stall is on an outside wall, before insulating the wall, seal the opening between the tub/shower and the exterior wall framing from crawl space or basement in one of two ways:
  - Seal with two-part foam or rigid material for larger openings, or
  - Cover opening with gypsum board. Cut hole and dense-pack cavity. Seal hole and gypsum board to surrounding framing materials with two-part foam (Figure 212-2-11).
- **Attic hatches and stairwell drops**: See section 213-5, "Attic Access Hatches".
- **Exterior wall top plates, low-pitch roofs:** tape handle of 2-part spray foam gun to broom stick; drill hole through handle and secure

Figure 212-2-11: Cavity beneath bathtub sealed with gypsum board and dense-packed with cellulose

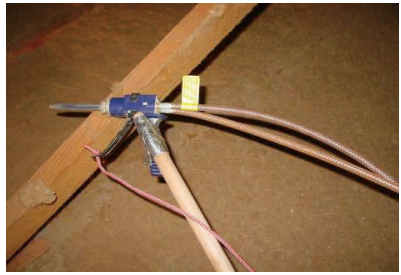


Figure 212-2-12: 2-part spray foam gun secured to broom stick with string attached to handle

Figure 212-2-13: Exterior wall top plate under low-pitch roof sealed with foam.

string (Figure 212-2-12); extend gun to top plate and seal (Figure 212-2-13).

- Whole House Fan[11]: Construct a durable, rigid enclosure on all sides of the fan housing that is taller than the surrounding insulation. Install an operable cover for the fan enclosure that opens when the fan is operated and closes when the fan is turned off. Operable lid must have an airtight seal when closed. Insulate fan enclosure to a minimum of R-20. Install insulation in full contact with the enclosure. Mechanically fasten insulation to fan cover.
  Apply a continuous seal at all seams, cracks, joints, and edges of enclosure. Provide an airtight seal for the enclosure cover when it is closed using weatherstripping, gaskets or equivalent.
- **Other openings in the pressure boundary**: Seal with rigid material, two-part foam, one-part foam or caulk depending upon size of opening.

212-3 General Air Sealing[12]

The following general infiltration items are done as air sealing measures when identified with the blower door.

- Joints in sill plate (mud sill) and around utility openings in siding and foundation shall be sealed in an appropriate manner. When a space between two metal surfaces is to be sealed, only a butyl or silicone caulk shall be used. Cracks between two masonry surfaces shall be sealed with cement patching compound or mortar mix. If the opening is deeper than 3/8 inch, follow procedures described above.
- Interior joints shall be caulked. These joints include where baseboard, crown molding and/or casing meet the wall/ceiling/floor surfaces. Gaps around mounted or recessed light fixtures and ventilation fans shall be caulked. Cover gap between the chimney and structural members (chase ways) in the pressure boundary (attic) with a heat resistant material

[11] SWS 3.0103.3, "Whole-House Fan – Operable"
[12] SWS 3.0101.1, "Air Sealing Holes"

(flashing, gypsum board, etc.) and seal with a compatible sealant.
- Low VOC sealants should be used whenever possible.

212-4 Bypass Sealing Materials
Materials used to seal air leakage sites must be nearly impermeable to air movement and form a continuous, nonporous surface over the opening being sealed. All materials must meet CFR440 specifications.

212-4-1 Worker Safety
When applying low pressure 2-part spray polyurethane foam, air purifying masks with an organic vapor cartridge and P-100 particulate filter shall be used. When applying high-pressure SPF insulation, supplied air respirators (SARs) will be used. Consult safety data sheet (SDS) for respiratory protection requirements.

Spray foam will be handled in accordance with manufacturer specifications or SDS standards to eliminate hazards with the use of foam. Appropriate personal protective equipment (PPE) shall be used.

212-4-2 Spray Foams
Spray foams may be used under counters and cabinets to seal bypasses but otherwise are not permitted to be used in the living area of home, with the exception of furnace closets located in the living space. Spray foams may be used in attics, unfinished basements, crawl spaces and attached or tuck-under garages.

Spray foams are either 1-part (sealant contained in one canister) or 2-part (chemicals contained in two canisters and mixed at the gun). 1-part foam is generally low or non-expanding. 2-part foam may expand 3 to 1.

Safety data sheets and manufacturer's instructions must be closely followed to ensure safety. Provide notification to the client of plans

to use two-part spray foam. Provide ventilation as necessary to prevent or dilute fumes that may get inside the home.

- 1-Part Foam (Figure 212-4-2-1)
  - **1-part foam dispensed through plastic nozzles is not permitted (Figure 212-4-2-2).** 1-part foam must be installed with a foam gun.
  - Surface areas to be foamed must be cleaned of dust and debris with a rag.
  - Surface areas to be foamed may be misted with water, particularly in cooler temperatures when humidity levels are low to help with adhesion.
  - Spray foam must be installed when the ambient temperature is between 40°F and 100°F, unless spray foam manufacturer recommends other temperatures.
  - Bead size should be no more than 2 inches.
  - 1-part foam should have a Flame Spread rating of 75 or less.

Figure 212-4-2-1: 1-part spray foam; foam canister is screwed onto a foam gun

Figure 212-4-2-2: 1-part spray foam dispensed through a plastic straw is not permitted in the Weatherization Program

- 2-Part Foam (Figure 212-4-2-3)
  - 2-part spray foam should be installed when the ambient temperature is between 60°F and 90°F unless spray foam manufacturer recommends other temperatures.
  - Spray foam canisters should be brought to 70°F to 80°F before use.
  - Surfaces to be foamed should be cleaned of debris.

- Should be used on gaps 2 inches or larger.
- 2-part foam should have a Flame Spread rating of 75 or less.

Figure 212-4-2-3: 2-part spray foam

212-4-3 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.

All openings 3/8 inch to 7/8 inch wide should be filled to within ½ 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
- Low VOC sealants should be used whenever possible.

212-4-4 Packing Materials[13]

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.

[13] SWS 3.0101.1c, "Backing, Infill, and Support"

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.

212-4-5 Air Barrier Materials

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 (drywall) should be used in interior applications where excessive moisture is not a problem and where flame retardant abilities are important. Drywall patches must be taped and at minimum have one finish coat of drywall mud applied. Patches should be sanded and ready to paint.
- Rigid foam board insulation

Air sealing materials such as rigid foam board must be sealed in place with caulk or spray 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.

213 Attic Insulation

213-1 Safety

Comply with fire and electrical safety procedures before insulating. Non-insulation contact (non IC rated) recessed light fixtures must be enclosed with 5/8 inch Type X gypsum board to prevent overheating and/or fire (Figure 213-1-1). 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.

Figure 213-1-1: Recessed light covered with drywall box

If there is insufficient clearance to install the box 4 inches higher than the insulation due to the roof pitch, box shall be equal to the height of the insulation and shall be covered with 5/8 inch Type X gypsum. Attic insulation shall not cover the top of the box. The box shall not be covered with gypsum board if there will be less than inch clearance between the top of the fixture and the gypsum board.[14]

[14] SWS 3.0102.1, "Sealing Non-Insulation Contact (IC) Recessed Light"

As an alternative to boxing, non-IC rated fixtures may be replaced with IC rated boxes or surface mounted fixtures. New fixtures must include LED lamps.

Alternately, commercially available recessed can covers may be used if they meet the following criteria.

- meet the fire rating requirements of 5/8 inch gypsum board (1 hour rating)
- meet the minimum clearances listed above,
- are non-vented, and
- are non-metallic[15].

- If recessed lights are certified as Insulation Contact (IC rated) and air-tight, they may have insulation installed directly over them. The blower door should be utilized to test the air seal of the light. Many times, the light fixture itself still needs to be air-sealed around the perimeter base where it meets the ceiling.
- Spray foam shall not be installed over light fixtures if fixture is IC rated.
- Existing bathroom exhaust fans do not have to be enclosed as described above unless the fans include a heat lamp and/or have incandescent lamps.
- New bathroom exhaust fans installed by the Weatherization Program must be rated such that they may be covered with insulation.
- Seal bypasses around heat producing devices, such as chimneys, B-vents and metal flues, with 26 gauge galvanized metal sealed with high temperature caulk to surrounding framing materials (Figure 213-1-2)[16]. A "fire block" spray foam is not permitted for this

Figure 213-1-2: Metal barrier around flue sealed with high temperature caulk

[15] To prevent condensation within the box
[16] SWS 3.0102.2, "Sealing High-Temperature Devices"

application. Vertical metal used as a barrier around heat producing devices must be securely fastened in such a manner as to not allow the barrier to collapse when insulation is installed (Figure 213-1-3). A minimum 3-inch clearance shall be maintained between barrier and heat producing device and shall extend a minimum of 4 inches above the finished level of the attic insulation.

Figure 213-1-3: Metal barrier around chimney

- Clearance of insulation from attic furnaces must be provided in accordance with the governing code.
- Ventilated insulation shields should be installed around wood-stove manufactured chimneys.
- Install insulation beneath active knob-and-tube maintaining a three-inch air space between insulation and wiring (Figure 213-1-4). Alternately, non-metallic channels or barriers, such as rigid foam board, should be installed to maintain minimum three-inch air space alongside of knob-and-tube wiring (Figure 213-1-5). Frayed wiring must be repaired and signed off on by a licensed electrician before adding insulation. Wiring splices must be enclosed in metal or plastic electrical boxes, fitted with cover plates. Closed electrical junction boxes may be covered with insulation, if marked with flags that are visible above the finished attic insulation level.

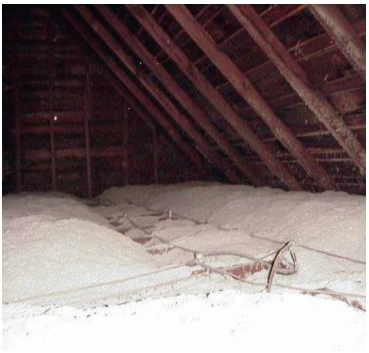


Figure 213-1-4: Attic insulation installed under knob-and-tube wiring

- The perimeter of attic fans should be dammed with 1-inch-thick nominal common lumber, plywood, metal shielding or minimum 1-inch-thick foam board.
- OSHA-approved breather masks must be worn when blowing insulation.

Figure 213-1-5: Rigid foam board used as barrier next to K&T wiring; floor cavity will be blown with cellulose insulation

213-2 Attic Insulation Preparation

213-2-1 Bypasses

Air leakage can significantly degrade the thermal resistance of attic insulation. All attic bypasses as previously described must be sealed before attic insulation is installed. **Where existing attic insulation is present, depressurize the house and check for leaks with a smoke puffer as smoke will be drawn through the insulation. Alternately, consider pressurizing the house with the blower door to help identify attic bypass locations (see section 212-1, "Testing").**

213-2-2 Roof Leaks

All roof leaks must be repaired before insulating attic. If roof leaks cannot be repaired, contact the Weatherization Agency.

213-2-3 Exhaust Fans

All kitchen and bath fans currently venting into the attic must be equipped with backdraft dampers and vented outdoors through roof, gable ends, soffits or eave fascia boards. Appropriate exterior termination kits such as wall caps, roof jacks and eave mounted vents shall also be installed if not present. Fans without operating dampers should be repaired or the fan should be replaced with a current ENERGY STAR rated fan. For additional information regarding bathroom exhaust fans and exhaust fan duct installation, see sections 505, "ASHRAE 62.2" and 507, "Exhaust Fan Ducts".

213-2-4 Top Plates

Existing batt insulation over top plates is not to be compressed with scrap wood or gypsum board. Compressed or ineffective insulation over top plates is to be replaced.

Figure 213-2-4-1: Foam blocking installed 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 (Figure 213-2-4-1). Cavity may be blocked with two-part spray foam (Figure 212-2-13), rolled fiberglass insulation or other rigid materials.

Mechanically fasten insulation baffles between foam or blocking and roof sheathing to maintain ventilation passageway. Insulation baffles or blocking material is not to compress insulation.

Figure 213-2-4-2: Soffit chutes extended above insulation

In rafter cavities where an insulation baffle is not installed or soffit venting is not present, ensure that cavity is blocked with a rigid barrier as described above to prevent over-spill into the soffit area.

Insulation baffles are to be installed only where soffit vents are present. When vented eaves or soffits exist, mechanically fasten insulation baffles in every rafter cavity that extend above the final insulation level by at least 6 inches. (Figure 213-2-4-2).

213-3 Unfinished Attics

213-3-1 Blowing Attic Insulation[17]

Efforts shall be made to achieve R49 when attic insulation is installed (Figure 213-3-1-1).

Figure 213-3-1-1: Required attic insulation R-value is a minimum of 49 or the maximum amount with an SIR greater than 1.0

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. Contractor shall install attic insulation markers throughout the attic area to ensure that insulation is installed to both a uniform and proper depth (Figure 213-3-1-2). At a minimum, one marker shall be installed for every 300 ft^2 throughout the attic. Markers shall be affixed to trusses or joists with the numbers a minimum 1 inch in height. Markers shall face such that they can be read from the attic access opening.

Figure 213-3-1-2: Attic insulation marker

Cellulose, blown rock wool or blown fiberglass insulation may be used to insulate unfinished attics. If cellulose insulation is used, it must be treated with boric acid which is used as a fire retardant (termed "borate only").

Note that the R-value of blown fiberglass begins to decrease significantly when the attic temperature drops below 30°F[18] and be

[17] SWS 4.0103.2d, "Installation"
[18] Building Research Council, University of Illinois at Urbana-Champaign, 1991

reduced by half when the attic temperature is -8°F[19]. The loss of R-value is due to establishment of convective air currents in the insulation. This is not a problem with cellulose insulation or fiberglass batt insulation.

Contractors and crews should note the condition of the ceiling finish before blowing cellulose. Cellulose weighs about twice that of blown fiberglass for the same R-value. If the work order calls for cellulose and the ceiling condition is poor, the Weatherization agency should be contacted about using fiberglass.

Do not blow insulation tight against roof deck, particularly over top plates. Cellulose should not be used where it may meet exposed metal roofing.

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 3.50 lbs/ft^3. Install blown fiberglass to a minimum density of 2.25 lbs/ft^3. Access these areas by drilling or removing the fascia board and tube filling each cavity. Ventilation is not needed when dense packing flat roofs.

213-3-2 Floored Attics
Remove attic flooring over joist cavities with live knob-and-tube wiring present and install barrier before insulating floor cavity (see Figure 2131-5). 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 3.50 lbs/ft^3. Install blown fiberglass to a minimum density of 2.25 lbs/ft^3[20].

[19] "Convective Loss in Loose-Fill Attic Insulation", Oak Ridge National Laboratory, 1992
[20] SWS 4.0103.6d, "Installation"

Flooring boards that have been removed are to be re-installed. With owner permission, flooring boards may be drilled and the cavity filled with blown insulation. Entry holes are to be sealed with plastic or wood plugs.

Dense pack floor insulation should be verified to prevent visible air movement using smoke.

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 (Figure 213-3-2-1).

Figure 213-3-2-1: Insulation blown under floor boards and then over floor boards where client storage is not needed

Durable insulation damming must be installed when insulating attics with adjoining spaces that are unconditioned. Such spaces often include attached garages and porches which are not to be insulated. Damming must be higher than the level of the attic floor insulation and mechanically fastened. (Figure 213-3-2-2)

Figure 213-3-2-2: Attic insulation damming barrier and dense pack platform

213-3-3 Batt Insulation[21]

Batt insulation must be installed in such a manner to ensure proper fit between ceiling joists. There must be no voids or gaps between batts or between batts and ceiling joists. Insulation must fill joist cavity and provide uniform and complete coverage. If insulation has

[21] SWS 4.0103.1, "Batt Installation"

vapor barrier backing, the vapor barrier shall be toward heated space. When insulation with vapor barrier is installed over existing insulation, the vapor barrier shall either be removed or slashed.

213-4 Cathedral Ceilings[22]

Damaged ceiling areas must be repaired before insulating. Contact Weatherization Agency if ceiling cannot be repaired. Do not insulate cathedral ceiling cavities that contain active knob and tube wiring that have not been tested for safety, thermal bypasses, open electrical boxes, blocking or recessed lighting fixtures.

Access to rafter cavities in cathedral ceilings may be gained through the soffit/fascia or interior ceiling.

Top and bottom of open rafter cavities shall be blocked with fiberglass or other blocking material. Dense pack cavities with cellulose insulation installed to a density between 3.50 lbs/ft^3. Blown fiberglass must be blown to a minimum density of 2.25 lbs/ft^3 to restrict the movement of air through it.

Interior access holes shall be plugged and sealed such that they can be painted by the client.

Attic ventilation is not needed when dense packing cathedral ceilings.

213-5 Attic Access Hatches[23]

If there is no interior access to the attic and access is gained through a gable vent for purposes of insulating, an interior access must be installed for purposes of conducting a final inspection.

Rough opening or attic access hatch must be surrounded with a durable insulation dam that is higher than the level of the attic floor insulation. Use rigid materials such as plywood that will support

[22] SWS 4.0102.3, "Inaccessible Ceilings – Dense Pack"
[23] SWS 3.0103.1, "Access Doors and Hatches"

the weight of a person when accessing the attic. The barrier's purpose is to prevent loose-fill insulation from falling out of the attic when the attic hatch is opened.

Attic hatches installed during weatherization should be large enough for a person to pass through and allow for a thorough inspection of the attic. Rough openings must be at least 4 square feet and at least 20 inches in width or length.

Attic access hatches shall be insulated to the same R-value as the attic insulation with foam board insulation – hatches are not to be insulated with batt insulation (Figure 213-5-1).

Figure 213-5-1: Attic hatch insulated with foam board; plywood blocking has been insulated with foam board

Blocking around attic hatch shall also be insulated. Attic insulation blown against and to the top of the blocking will suffice. Foam board may also be used to insulate the blocking if the attic insulation does not insulate to the top of the blocking.

Weatherstrip, other than peel-&-stick foam, shall be used to seal the attic hatch. Latches, sash locks, gate hooks or two ½ inch thick pieces of gypsum board attached to the hatch are to be used to provide positive closure.

Figure 213-5-2: Box around retractable attic stairs

Attic hatches must not be permanently sealed and installed in such as fashion as to allow for inspection.

A box shall be built and installed over retractable attic stairways (Figure 213-5-2).

Hatches shall be insulated to R49 or the maximum R-value structurally allowable up to the R-value of the adjoining insulated assembly. Pull-down stair rough opening will be surrounded with a durable dam that is higher than the level of the attic floor insulation.

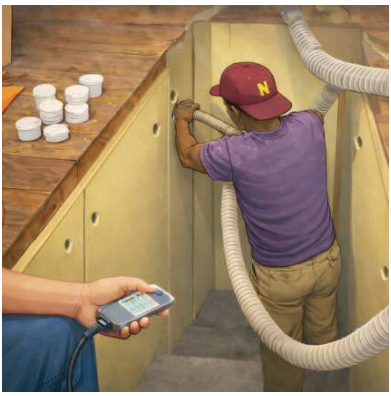


Figure 213-5-3: Stairwell walls being dense-packed

If attic is accessed by a stairwell and a standard vertical door, dense-pack cellulose insulation should be blown into walls of the stairwell leading to passage door of the unheated attic (Figure 213-5-3) as well as the cavity beneath the stairs. Determine if blocking exists to stop insulation from filling other areas by mistake when planning to insulate walls and stairway. Install threshold or door sweep and weatherstrip door.

213-6 Finished Attics

The finished attic consists of five sections (Figure 213-6-1).

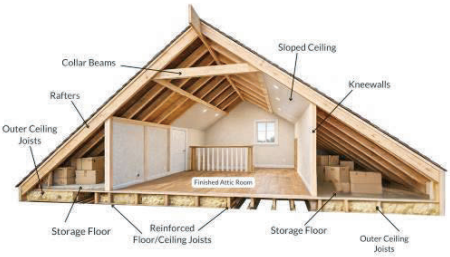


Figure 213-6-1 Attic sections

- Exterior finished attic walls (end walls of finished attic)
- Collar beams (above finished attic)
- Sloped roof (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)

Attic bypasses shall be sealed before insulating.

213-6-1 Exterior Finished Attic Walls
Insulate exterior finished attic walls per section 214, “Wall Insulation”.

213-6-2 Collar Beams & Outer Ceiling Joists
Insulate collar beams and outer ceiling joists per section 213-3, “Unfinished Attics”.

213-6-3 Sloped Roof (roof rafters)
Sloped roofs (roof rafters) 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 3.50 lbs/ft^3.

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.

213-6-4 Knee Walls
Open knee wall cavities may be insulated in one of four manners. One method may be used for closed cavity knee walls.

- Open Cavity – Single Batt
- Open Cavity – Double Batt
- Open Cavity – Spray Foam
- Open Cavity – Dense Packed
- Closed Cavity Knee Wall

Knee walls may also be within the conditioned space. If so, roof rafters shall be insulated and air sealed rather than the knee walls. See “Knee Wall within Conditioned Space”.

Open Cavity – Single Batt[24]

Insulate knee walls with maximum R-value as allowed by stud cavity depth (Figure 213-6-4-1). Extend batt insulation down to bottom plate of knee wall. Ensure that joist cavity beneath knee wall has been air sealed (see section 212-2, "Sealing Bypasses"). Insulation shall fit snugly between the studs.

Figure 213-6-4-1: Knee walls insulated with fiberglass insulation

Batt insulation should be installed with the kraft paper installed towards the conditioned space. Batt insulation installed with fibers exposed to the knee wall cavity shall be covered with an air barrier material to prevent convective looping within the insulation and to prevent fiberglass exposure. House wrap material or a "belly patch" may be used to cover the insulation. Install an airtight vapor permeable backing material in full contact with the existing cavity insulation.[25]

Open Cavity –Double Batt

Knee wall insulation R-value may be increased with the addition of another layer of batt insulation.

- Install first layer of batt insulation as described above but with the kraft paper facing out towards the knee wall cavity.
- Secure insulation by stapling the flanges to the face of the knee wall studs – no inset stapling.
- Install second layer of faced batt insulation horizontal to the first layer of insulation. Kraft paper should face towards the

[24] SWS 4.0104.2, "Knee Wall – Batt Insulation"
[25] SWS 4.0104.2e, "Install backing"

knee wall. Secure second layer of insulation by face stapling insulation flanges to the knee wall studs.

- Enclosed exposed fibers of insulation with a house wrap air barrier as described above.

Open Cavity – Spray Foam[26]

Install closed-cell spray foam to back side of knee wall finish. Insulation shall be a minimum 3 inches thick (R18). An air barrier over the insulation is not required.

Separate spray foam from living space with a thermal barrier material (e.g., 1/2" gypsum wallboard) as specified by applicable building code.[27] Generally, the interior knee wall finish of drywall or plaster will satisfy this requirement.

If knee wall cavity is used only for the service of utilities, spray foam will be separated from the knee wall cavity using a suitable ignition barrier covering or coating according to manufacturer's specifications.

If knee wall cavity is used for storage or occupancy, spray foam will be separated from the attic space using a thermal barrier material (e.g., 1/2" gypsum wallboard) as specified by applicable building code and manufacturer specifications.

[26] SWS 4.0104.5, "Knee Wall – SPF With No Existing Insulation"
[27] SWS 4.0104.2f, "Ignition and Thermal Barriers"

Open Cavity - Dense Packed[28]
Close-in knee wall studs with house wrap material, "belly-patch" or minimum ½ inch insulated foam sheathing 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. Polyethylene or similar vapor barrier material shall not be used for knee wall enclosure.

Figure 213-6-4-3: Knee walls being dense-packed with cellulose

Cut holes in knee wall material and insulate with dense pack cellulose (3.5lbs/ft^3) or fiberglass (2.25 lbs/ft^3) (Figure 213-6-4-3).

Closed Cavity - Knee Wall
Insulate closed cavity knee walls per section 214, "Wall Insulation".

Knee Wall within Conditioned Space[29]
Insulate rafter cavity with maximum R-value as allowed by rafter cavity depth when space behind the knee wall is considered part of the conditioned space. The attic floor cavity over the top plate must be

Figure 213-6-4-4: Connecting roof thermal boundary to sidewall thermal boundary with rigid foam board insulation; 2-part spray foam will also work

[28] SWS 4.0104.1, "Knee Wall – Dense Packing"
[29] SWS 4.0102.3, "Inaccessible Ceilings – Dense Pack"

air sealed and insulated to connect the thermal boundary from the sidewalls to the roof (Figure 21364-4). Use rigid foam board or 2-part spray foam insulation.

213-6-5 Knee Wall Hatches

The access should be properly framed, be as wide as the knee wall stud cavity and be a minimum 20 inches high. The access cover should be a durable, rigid material and securely attached with appropriate hardware to provide recurring access. Access hatch should be weatherstripped with something other than peel-&-stick foam. Hatches should be insulated to the same R-value as the knee walls with a minimum of R-value of 13. Batt or foam board insulation may be used. Window casing may be used as interior trim around hatch opening. Joints in the casing should be caulked prior to painting.

Existing knee wall access hatches should be weatherstripped (no peel-&-stick foam) and insulated with a minimum of R13 batt or insulated foam board (Figure 213-6-5-1). A new access cover of a durable rigid material should be installed if necessary.

Hatches should be installed in such a fashion as to allow for inspection.

Figure 213-6-5-1: Knee wall hatch insulated and weatherstripped

213-7 Attic Venting[30, 31]

Installing attic ventilation or increasing attic ventilation is an optional measure and is left to the discretion of the Weatherization Agency. There may be instances where local code will require that additional attic vents be installed.

There are very few reasons to install attic ventilation. The actual color of the roofing medium or shingles has the most impact on solar heat gain or reflection. The focus should be on controlling indoor relative humidity issues and sealing attic bypasses rather than calculating vent area and determining vent locations. If attic vents are included as part of an overall attic air sealing/insulation strategy, the following guidelines are to be met.

- Vent devices are not to permit rain or snow to enter the attic.
- Ridge vents are not to be installed on hip rafters.
- The structural integrity of a roof system should not be compromised for the sake of installing attic ventilation.
- Venting in an attic does not make it acceptable to terminate bathroom, kitchen or dryer vents in the attic.
- If roof vents must be installed, an effort is to be made to install them on the least visible roof surface.
- Attic vent types will be made of corrosion resistant material for their specific location.
- Attic vents will have screens with non-corroding wire mesh openings of 1/16 inch to ¼ inch to prevent pest entry.

Note that the installation of attic vents may be called for on the work order if an attic fan is present and there are insufficient vents for make-up air when the fan is operating.

[30] The following findings are taken from "Venting of Attic and Cathedral Ceilings" by William B. Rose and Anton TenWolde from the ASHRAE Journal, October 2002.

[31] SWS 4.0188.2, "Unconditioned Attic Ventilation"

213-8 Insulation Certificate

Contractors and crews installing blown-in insulation must permanently fasten a signed certificate near the electrical panel, on the furnace, or in an accessible location specified by the Weatherization Agency, that attests to the company name, date installed, insulation brand name, installed thickness, minimum settled thickness, R-value added, square footage, thermal resistance chart, conformance to federal specifications, and the number of bags installed in the attic.[32]

Attic insulation markers shall be placed in locations throughout the attic such that insulation depth and uniformity of coverage can be inspected (Figure 213-8-1). At a minimum, one marker shall be installed for every 300 ft^2 throughout the attic. Markers shall be affixed to trusses or joists with the numbers a minimum 1 inch in height. Markers shall face such that they can be read from the attic access opening.

Figure 213-8-1: Attic insulation marker

Contractor shall securely fasten markers or flags at all utility junction boxes that can be seen above the final level of the insulation.[33]

Contractor shall post a signed and dated receipt that minimally includes installed insulation type, coverage area, installed thickness, and installed R-value for all attics[34].

[32] SWS 4.0103.2e, "Insulation – Onsite Documentation"
[33] SWS 4.0103.2c, "General Preparation"
[34] SWS 4.0104.2g, "Insulation – Onsite Documentation"

214 Wall Insulation[35]

214-1 Wall Insulation Preparation

Inspect walls for evidence of moisture damage. If existing condition of the siding, sheathing or interior wall finish indicates an existing moisture problem, contact Weatherization Agency.

- Inspect indoor areas on exterior walls to assure that they are strong enough to withstand the application process. Contact Weatherization Agency if problems are found on walls that would prevent sidewall insulation from being installed.
- Inspect wall cavities for active knob-and-tube wiring. Wall cavities that contain active knob-and-tube wiring are not to be insulated.
- Gaps in exterior window trim and other areas that may leak water into the wall must be sealed.
- Seal interior openings from which insulation may escape, such as pocket doors, balloon framing and unbacked cabinets, soffits, and closets.
- Remove siding and drill through sheathing. If siding cannot be removed, contact Weatherization Agency.
- Asbestos siding may be removed (Figure 214-1-1). Decision to remove asbestos siding should be made on a home-by-home basis considering condition of siding. Precautions shall be taken so as not to damage siding. Asbestos siding should never be cut or drilled. If possible, insulate walls from the interior (see next bullet point).
- Insulation may be installed from the interior after written approval from the homeowner is obtained by the Weatherization Agency. Interior holes drilled for insulation

Figure 214-1-1: Asbestos siding that has been removed

[35] SWS 4.0202.1, "Dense Pack Insulation"

must be finished, primed and made ready for painting by the client or covered by trim/chair rail as agreed upon with client.

- Wall cavities must be probed to identify fire blocking, diagonal bracing or other obstacles. Drill additional holes as necessary to ensure complete coverage.
- Pulley wells no longer used for window operation must be packed with insulation. Holes may be drilled through the jamb and sealed with plugs following installation of insulation.
- Blowing machine pressure test will be performed with air on full, feed off, agitator running and gate closed. Hose outlet pressure should be at least 96 *IWC* or 3.5 *psi* for cellulose insulation; for other types of *dense pack* insulation, check manufacturer specification for blowing machine set up.

214-2 Dense-Packed Wall Insulation - Cellulose

- Contractors and crews installing dense-packed cellulose wall insulation must be certified to do so by the Illinois Weatherization Program.[36]
- Install insulation in accordance with the manufacturer's recommended application procedure.
- Drill minimum two- to three-inch diameter holes to access stud cavities. Avoid drilling holes in vicinity of electrical outlets and switches.
- Dense-packed wall insulation is best installed using a blower equipped with separate controls for air and material feed. The recommended insulation blower takeoff pressure should be at

Figure 214-2-1: Dense-pack cellulose being installed

[36] Contractor certification for dense-packed cellulose installation is an ongoing Program by IHWAP. Non-certified contractors and crews can continue to install dense-packed cellulose but must become certified as soon as feasibly possible.

least 3.5 pounds per square inch at the exhaust port (96 inches of water column).

- Cellulose insulation must be blown to a minimum of 3.50 pounds per cubic foot density (Figure 214-2-1). This minimum density translates into just over one pound per square foot in a two-by-four wall cavity. Blowing cellulose insulation this densely requires a fill-tube. An eight-foot cavity should hold a minimum of 10 pounds of insulation[37].
- The fill tube should be 1 inch or 1 ¼ inch inside diameter tubing with the appropriate stiffness for the job and outdoor temperature.
- Fill-tubes should be marked with one-foot intervals to verify the correct penetration of the tube into the wall.
- Except as previously noted, fill all wall cavities. In some cases, wall cavities close to critical framing junctures will take more insulation to plug and fill, which is often necessary to assure proper air sealing of the house.
- All wall cavities shall be completely filled with insulation leaving no voids.
- Cut additional holes above or below stud cavity obstructions if necessary to fill cavity.
- Seal the holes with expandable foam or stuff tightly with fiberglass and cover with sheathing tape. Cover the hole with adhesive backed roofing paper, such as “ice & water shield” (Figure 214-2-2). Attach with minimum two staples to

Figure 214-2-2: Hole sealed with sheathing tape

[37] Start with several full height, unobstructed wall cavities to measure the insulation density and adjust the machine settings. Start with an empty hopper. Fill the hopper with a bag with a known weight. An eight-foot cavity should consume a minimum of 10 pounds of insulation. For most insulation brands, the hopper will empty of insulation just before the third 8-foot wall cavity is full, assuming about 3.5 pounds per cubic foot density.

hold in place. Tapered wood or plastic plugs may also be used.
- Dense pack insulation will be verified to prevent visible air flow at 50 pascals of pressure difference.

Two-hole method
If the interior wall finish is too weak for dense-pack installation, the two-hole method is permitted only if approval is received in advance of the work from the Weatherization Agency. Examples of weak interior finish include plaster and lath in poor condition, drywall that is less than 1/2" thick and in poor condition and wall paneling used as the interior finish.

- Drill 2 one-inch diameter holes into each stud cavity.
- Holes are to be located no more than 2 feet between the top plate and the top holes; 2.5 feet between the bottom plate and bottom holes.
- Examine wall cavity with wire probes or steel tape to determine location of cavities around window and door areas.
- Insulation to be installed in accordance with manufacturer's recommended application procedures.
- All wall cavities shall be completely filled with insulation leaving no voids.
- All wall cavities around windows and doors are to be filled with insulation.

214-3 Dense-Packed Wall Insulation – Fiberglass

- Contractors and crews installing dense-packed fiberglass wall insulation must be certified to do so by the Illinois Weatherization Program.
- Access to wood frame sidewalls shall be per section 214-1, "Wall Insulation Preparation".
- Install insulation in accordance with the manufacturer's recommended application procedures.
- Dense-packed fiberglass wall insulation must be installed to a minimum density of 2.25 pounds per cubic foot density. One 30 pound bag should fill 5 typical 2" x 4" x 8' stud cavities to achieve this density. This equates to about 0.65#/ft^2.

- Drill minimum two- to three- inch diameter holes to access stud cavities. Avoid drilling holes in vicinity of electrical outlets and switches.
- The fill tube should be 1 inch or 1 ¼ inch inside diameter tubing with the appropriate stiffness for the job and outdoor temperature.
- Cut additional holes above or below stud cavity obstructions if necessary to fill cavity.
  - Seal the holes with expandable foam or stuff tightly with fiberglass and cover with sheathing tape. Cover the hole with adhesive backed roofing paper, such as "ice & water shield". Attach with minimum two staples to hold in place. Tapered wood or plastic plugs may also be used.

Figure 214-4-1: Injection foam being used to insulate wood frame wall

Figure 214-4-2: Injection foam used to insulate brick veneer wall

214-4 Injection Foam

- Contractors and crews installing injection foam wall insulation must be certified to do so by the insulation manufacturer.
- Documentation of the "Test Box" weight, and "Break Test" shall be submitted to the Weatherization Agency with invoicing documents.
- Access to wood frame sidewalls shall be per section 214-1, "Wall Insulation Preparation".

- Install insulation in accordance with the manufacturer's recommended application procedures (Figures 214-4-1 and 2).
- Stud cavities shall be completely filled with no voids or gaps.
- Air space between brick veneer and exterior wall sheathing shall not be filled with foam.
- Walls with existing batt insulation may be insulated with injection foam.
- Access to fur cavity in masonry buildings may be gained by drilling through the interior finish. Holes must be finished and made ready for painting by the client (Figure 214-4-3).

Figure 214-4-3: Holes sealed and ready for painting

214-5 Bandjoist Insulation

The bandjoist is the area between floors in a multi-story home. The bandjoist should be included as part of a sidewall insulation retrofit. Only those parts of these floor cavities that border the exterior must be insulated.

In platform-framed buildings, these cavities must be accessed from the rim or bandjoists. In balloon framed buildings, these cavities are usually open to the walls, allowing access from the rim or bandjoists and also from the wall cavities above or below these floor cavities. The R-value of the insulation in these floor cavities must be at least equal to the R-value of the insulation installed in the adjacent wall cavities.

Follow "Preparation" guidelines as described in section 214-1, "Wall Insulation Preparation". Pay particular attention to location of light fixtures, exhaust fans, wiring and ductwork located in ceilings between floors.

- Remove exterior finish material as described above in section 214-1, "Wall Insulation Preparation".

- Drill 2 inch or 2-1/2 inch diameter holes to access each cavity between ceiling joists.
- Insert nozzle into *Insul-Bag* (or similar product) and fill bag.
- Alternately, insert hose nozzle in cavity. Reduce air setting and raise flow on the hopper. Spray insulation into cavity. The objective is to create an "insulation plug" in the ceiling cavity usually within 3 feet to 4 feet from the bandjoist. Alternately, a 90º nozzle may be inserted into the cavity. An "insulation plug" will be created closer to the bandjoist by spraying insulation up against the subfloor.
- Joist cavities on the remaining two sides of the home (where joists are parallel to the bandjoist) should be completely filled with insulation. Insert rigid fill tube half the width of the cavity. Pack the joist cavity with insulation.

214-6 Open-Cavity Wall Insulation[38]

Batt insulation must be cut to the exact length of the cavity. Each wall cavity should be completely filled with batt insulation.

- If possible, use unfaced friction-fit batt insulation. Fluff to fill entire wall cavity.
- Staple faced insulation to outside face of studs - no inset stapling.
- Split batt around wiring rather than letting the wiring bunch the batt to one side of the cavity.
- Insulate behind and around obstacles with scrap pieces of batt or spray foam before installing batt.
- Install vapor retarder if required. Vapor retarder shall have a perm rating less than one on the warm in winter side of the insulation. Vapor retarder should be well fastened at all seams and edges.
- Installed fiberglass insulation exposed to the interior living space must be covered with minimum 1/2-inch drywall or other material that has an ASTM flame spread rating of 25 or less.

[38] SWS 4.0201.2, "Batt Insulation"

214-7 Completion of Wall Insulation[39]

Ensure that no insulation dust or debris have been left in or around the house.

Duct system shall be inspected to assure that ducts are free of insulation. Turn on air handler and look for signs of insulation.

Provide information on the wall insulation application levels (R-value, quantity of insulation, etc.) required by the certificate of insulation to be given to the client, and posted near the electrical panel, on the furnace, or in an accessible location specified by the Weatherization Agency.

214-7-1 Post Installation Verification

For the required verification, drill a hole in the exterior of the house, depressurize with the blower door, and use smoke to determine if the wall cavity is dense packed properly. If smoke is not drawn into the cavity, the cavity is airtight/sealed.

An infrared (IR) camera, when available, may also be used as a post installation quality control aid in conjunction with a blower door depressurization test. The IR camera can verify uniform insulation coverage. The IR camera can also help identify thermal anomalies consistent with voids or incomplete fills. Note that the IR camera does not replace:

- Required insulation density
- Bag count verification
- Pressure diagnostics or airflow verification at 50 pascals

It is highly recommended that users of IR cameras receive basic training in IR thermography with respect to:

- Thermal pattern recognition
- IR camera limitations

[39] SWS 4.0202.1h, “Insulation – Onsite Documentation"

Note that the use of IR cameras as a post inspection tool is not required by IHWAP. However, it is considered a "Best Practice" that reflects IHWAP's continued movement toward improved diagnostics, higher installation accuracy and enhanced quality assurance.

215 Crawl Space Insulation

The thermal boundary of a crawl space in site-built homes can either be the foundation walls or the floor above the crawl space. Refer to sections 215-1, "Crawl Space Foundation Insulation," 215-4 "Ground Moisture Barrier," and 514 "Code Compliance" for guidelines on bringing a crawl space into the conditioned envelope.

The floor is always the thermal boundary in mobile homes. The thermal boundary in manufactured homes can either be the foundation walls or the floor. The distinction is that mobile homes are not on a permanent foundation. Manufactured homes, though built in a factory, are placed on permanent foundations such as concrete block or poured concrete. In this respect, they are very similar to site-built homes.

The following items are required regardless of the location of the crawl space thermal boundary.

- Exhaust fans that vent into a crawl space must be ducted to the outside before crawl space insulation is installed. See section 507, "Exhaust Fan Ducts".
- An effective ground moisture barrier must be present or one should be installed as part of weatherization, regardless if the crawl space will be insulated (see section 215-4, "Ground Moisture Barrier", for exceptions.)
- Install a durable (minimum of 10-year service life), easily seen sign, sized a minimum of 8.5"x 11" at each access to the space. Sign shall minimally include the following items[40]:
  - Warning to prohibit storage of hazardous and flammable materials.

[40] SWS 2.0202.1h, "Signage"

- Caution not to damage the ground vapor retarder, air barrier, insulation, and mechanical components specific to the space.
- Immediate repairs are needed in the case of damage.

215-1 Crawl Space Foundation Insulation

Crawl space foundation walls are not to be insulated unless existing crawl space moisture problems can be corrected. Contact the Weatherization Agency if existing moisture problems are found.

Figure 215-1-1: Foil-faced rigid foam board on foundation walls, vents sealed and continuous and

Extruded polystyrene and polyisocyanurate insulation are the most appropriate insulation types for flat concrete or concrete block walls (Figure 215-1-1)[41]. Rigid foam board insulation used for foundation wall insulation shall be a minimum R10 and should extend from the top of the foundation wall down to the crawl space floor.

Figure 215-1-2: Two-part spray foam applied to foundation wall with ground cover

Two-part spray foam is also an option for insulating foundation walls and care must be taken to assure that the proper thickness is obtained (Figure 215-1-2)[42]. 2-part foam insulation shall be a minimum R14 (2 inches thick).

One inch of 2-part foam may be used

[41] SWS 4.0402.2, "Closed Crawl space – Rigid Foam Insulation"
[42] SWS 4.0402.3, "Closed Crawl space – SPF Insulation"

as an air sealing measure if the foundation material is brick, block or stone. This measure is not acceptable for poured concrete foundations.

Figure 215-1-3: Example of fibrous foundation wall insulation

Fibrous insulation, like a faced metal building insulation blanket, may be used on crawl space foundation walls.[43] Fibrous insulation must have a flame spread/smoke development index of 25/450 or less and must include a facing that is a class II vapor retarder (less than 1.0 perm). A good example of fibrous insulation that meets these requirements is shown in Figure 215-1-3.

Fibrous insulation shall be a minimum R10 and be in full contact with foundation wall. Insulation shall be mechanically fastened to foundation. Seams, joints and connections in the insulation shall be sealed with a compatible sealant (tape, mastic, adhesive).

If crawl space is used only for the service of utilities, foam insulation and spray foam shall be separated from the space using a suitable ignition barrier covering or coating according to manufacturer's specifications[44]. Alternatively, spray foams that are infused with an ignition or thermal barrier and are rated for crawl spaces can be used.

If crawl space is used for storage or occupancy, foam insulation and spray foam shall be separated from the space using a thermal barrier material (e.g., 1/2" gypsum wallboard) as specified by

[43] SWS 4.0402.1 “Closed Crawl Space – Non-Foam Insulation”
[44] SWS 4.0402.3i, “Ignition and Thermal Barriers”

applicable building code and manufacturer specifications. See section 202, “Ignition and Thermal Barriers”, for further guidance.

Insulation may be left exposed without an ignition barrier or thermal barrier if specifically approved for such installation in the product specification documentation (such as the ICC-ES Report).

Existing foundation vents are to be sealed. If foundation vents cannot be sealed, contact Weatherization Agency. Foundation wall insulation is not to be installed unless the crawl space vents can be sealed.

- Air sealing the foundation wall is to be completed before foundation insulation is installed.
- A ground air-moisture barrier shall be installed that extends up the foundation walls at least 6 inches. The barrier shall be sealed to the foundation walls with an appropriate sealant. See section 215-4, “Ground Moisture Barrier.”
- If water seepage through foundation is suspected, barrier may be installed up to and attached to the sill plate. Barrier must be continuous from ground to sill plate to prevent water from draining through it. Seams shall be minimized.

Figure 215-1-4: Combustion air intake from crawl space; floor above crawl space is thermal boundary

- Overlap seams at least 12 inches using reverse or upslope lapping technique and seal with acoustical sealant or 3M #8087CW builders’ tape or equivalent. Seams are not to be sealed with spray foam.
- Insulation should be attached to the entire wall surface with appropriate fasteners.
- Install insulation with no significant voids or edge gaps.
- If heating system is located in crawl space or combustion air is drawn from the crawl space, precautions must be taken to

assure that adequate combustion air is available (see section 311-1-3, “Combustion Air”). Consideration should be given to insulating the floor above the crawl space if a combustion appliance is located within the crawl space or if combustion air cannot be drawn directly from the exterior (Figure 215-1-4).

- Exposed pipes and ducts are to be insulated if combustion air is provided to a heating system located in the crawl space.
- Exhaust fans or dryer vents that terminate in a crawl space must be ducted to the outside before insulating the foundation wall (see section 507, “Exhaust Fan Ducts”).

Figure 215-2-1: Insulation should fill floor cavity

215-2 Crawl Space Floor Insulation

Floors above crawl spaces may be insulated if they form the thermal boundary.

All appropriate measures shall be taken to establish an effective air barrier at the floor, to prevent air from passing through or around the insulation (see section 212-2, “Sealing Bypasses”).

- As the floor above the crawl space is the thermal boundary, foundation vents may be ignored except where required to provide combustion air to combustion appliances located in the crawl space. If combustion appliances are located in the crawl space, vent sizes shall be checked to assure adequate combustion air supply (see section 311-1-3, “Combustion Air”).
- **Insulation must contact subfloor to prevent convection above the insulation.**

Crawl space floor joist cavities may be insulated in one of four manners.

- Batt insulation
- Spray foam
- Dense Pack with Rigid Barrier
- Loose Fill with Netting

Figure 215-2-2: Twine used to hold batt insulation in floor above crawl space

Batt insulation[45]

Batt insulation used to insulate floor joist cavity should be the maximum R-value structurally allowable by the floor framing (Figure 215-2-1). Kraft faced batts must be installed with the kraft facing the subfloor. **Unfaced batt insulation is not allowed.**

Batt insulation must be securely fastened to framing with insulation hangers or other supporting material. Friction fitting or stapling of floor insulation are not appropriate methods. The following methods are acceptable.

- Wood lath and galvanized nails may be used to hold the insulation in place with a maximum spacing of 18 inches on center.
- Twine used to hold the insulation in place must be made of polypropylene, nylon or polyester with a breaking strength of at least 150 lbs and 12 inch maximum spacing between anchor points on the same joist (Figure 215-2-2).

Figure 215-2-3: Compressed insulation due to insulation support

- Wire used to hold the insulation must be zinc coated, stainless or similar corrosive resistant material with a minimum diameter of .035". Wire must be spaced no more

[45] SWS 4.0301.1, "Batt Insulation"

than 18 inches apart. Supports and anchors must be zinc coated, stainless steel or similar corrosion resistant material.
    - Wire hangers may also be used if spaced no more than 18 inches on center and have a minimum thickness of .090 inches. The hanger ends must penetrate the floor joist at least ½ inch.
    - Other approved netting or fabric, such as plastic fencing
- Insulation supports shall not compress insulation by more than one inch (Figure 215-2-3).
- Insulation shall be fitted tightly around cross bracing and other obstructions.
- Batt insulation shall be installed with the facing placed up towards the floor sheathing
- Ensure that floor insulation is in direct contact with box sill. If balloon framed, air seal stud cavities prior to installing insulation.
- Insulation shall be installed without voids or edge gaps.
- Exposed pipes and ducts must be insulated.
- Install a ground air-moisture barrier per section 215-4, "Ground Moisture Barrier."

Spray foam[46]

Two-part spray foam insulation may be used to insulate the floor. Spray foam insulation must provide a minimum 3 inches (R18) against the floor deck. A minimum of 1 inch spray foam must encapsulate (sides and bottom) the floor joists and cross bracing or blocking. All members of open web floor joists shall also be encapsulated with a minimum of 1 inch foam.

A thermal barrier is required if the crawl space can be used as auxiliary living space or used for storage. Ignition barriers are required whenever the crawl space is not or

[46] SWS 4.0301.5, "SPF in Open Joisted Cavities"

could not reasonably be used as an auxiliary living space or for storage. Criteria may include difficulty of entry (for example, a hatch or opening not easily accessible)[47].

Dense Pack with Rigid Barrier[48]

A rigid air barrier must be mechanically fastened to the underside of the floor framing system. Seams and penetrations shall be sealed. Dense pack insulation shall completely fill the floor cavity. Cellulose shall be installed at a minimum density of 3.5 #/ft^3 and fiberglass shall be installed at a minimum density of 2.25#/ft^3. All holes made for insulation installation and other penetrations shall be sealed.

Install a ground air-moisture barrier per section 215-4, "Ground Moisture Barrier."

Figure 215-3-1: Peel & stick weatherstripping is not permitted

Loose Fill with Netting[49]

Use insulation manufacturer approved netting or fabric and install to underside of floor framing per insulation manufacturer's recommendations. Fill floor cavity to manufacturer's recommended density to achieve desired R-value. Floor cavity must be completely filled with insulation.

Install a ground air-moisture barrier per section 215-4, "Ground Moisture Barrier."

[47] SPFA-126, "Thermal Barriers and Ignition Barriers for the Spray Polyurethane Foam Industry"
[48] SWS 4.0301.4, "Dense Pack in Joisted Cavities with Rigid Barrier"
[49] SWS 4.0301.2, "Loose Fill with Netting/Fabric in Joisted Cavities"

215-3 Crawl Space Access

Crawl space access hatches from conditioned areas to unconditioned areas should be weatherstripped and insulated to a minimum of R10. Peel-&-stick weatherstrip is not permitted to be used on crawl space hatches (Figure 215-3-1). Access covers must be easily removable for entrance into the crawl space (Figure 215-3-2).

Figure 215-3-2: Crawl space access hatch; weatherstripped and easily removable

Outside access hatch shall be securely attached to foundation wall and insulated to minimum R10 and weatherstripped if foundation walls form the thermal boundary. Positive closure (latch, sash locks, gate hooks, barrel bolts, etc) shall be installed to provide substantially airtight closure.

215-4 Ground Moisture Barrier[50,51]

Ground moisture barriers are required regardless of the crawl space thermal boundary location. They are also required whether or not the crawl space will be insulated. The following are exceptions.

- The crawl space is not accessible,
- The crawl space is supported on piers (Figure 215-4-1), and
- Mobile homes.

Figure 215-4-1: Crawl space supported on piers

Ground moisture barriers may be added to help solve an existing moisture problem regardless of the exceptions.

[50] SWS 2.0202.1, "Unvented Subspaces – Ground Cover"
[51] SWS 2.0202.2, "Vented Subspaces – Ground Cover'

Crawl space moisture can lead to condensation, mold and rot. Air passing through the soil can contain radon and pesticides. Covering the ground with an airtight moisture barrier establishes an air barrier and seals out moisture and soil gases.

Figure 215-4-2: Minimum 6 mil ground cover; sealed to foundation wall with 2-part foam

Ground moisture barriers should be minimum 6 mil polyethylene plastic (Figure 215-4-2). Complete or partial coverage of ground moisture barriers will depend on the accessibility and working conditions in the space. If the entire crawl space floor is not accessible, cover as much as possible.

- Ground moisture barriers shall be installed and sealed in accordance with ASTM E1643 and manufacturer's recommendations.
- Ground moisture barriers must meet tear and puncture resistance standard ASTM E1745.
- Cover the ground completely with a ground moisture barrier without voids or gaps.
- When ground moisture barrier is installed on sloping ground or accessed for routine maintenance or storage it shall be fastened to ground with durable fasteners or ballast(s).
- Where HVAC equipment is located in the crawl space, the ground cover between the access opening and equipment shall be protected with a vinyl runner or other mat-like product.
- Extend air-moisture barrier up foundation wall a minimum of 6 inches. Seal ground moisture barrier to foundation wall with acoustical sealant, 2-part spray foam or another effective adhesive. Furring strips can be used to further secure ground cover to foundation wall.

- Seal ground moisture barrier to foundation before installing insulation.
- Overlap ground moisture barrier at least 12 inches and seal seam with acoustical sealant or 3M #8087CW builders' tape or equivalent. Seams are not to be sealed with spray foam.
- Seal the ground moisture barrier to concrete footings with acoustical sealant or another effective adhesive.

Figure 215-4-3: Condensate line draining on top of ground moisture barrier

- Duct tape may also be used to temporarily seal the ground cover to the foundation wall and to seal joints between sheets. Embed the duct tape in duct mastic assuring that the mastic extends a minimum of 3 inches beyond the edge of the duct tape. Duct tape by itself may not be used to seal ground cover to foundation walls or joints between sheets.
- For air conditioner condensate lines draining into a crawl space (Figure 215-4-3) best practice is to redirect the line so that it conveys all condensate to the exterior of the building. If exterior redirect is not possible, redirect the line to the sump pump pit or install a condensate pump and run the line to a suitable existing drain (e.g., standpipe, washer box). Alternatively, install a French drain in the crawl space and ensure that it is all underneath the ground moisture barrier.

215-5 Crawl Space Ventilation

Installing crawl space vents is a non-allowable weatherization measure, unless needed to provide adequate combustion air to combustion heating appliances located there. If combustion air to the heating appliance is taken from the crawl space, see product manufacturer's instructions for correct combustion

air intake size. See section 311-1-3, "Combustion Air", for additional information.

Crawl space ventilation will not solve typical moisture problems found in crawl spaces. The source of the moisture must be identified and, if possible, corrected.

Vents in crawl spaces with the foundation wall being the thermal barrier may be sealed with rigid insulation and a metal finish (Figure 215-5-1).

Figure 215-5-1: Insulated vent with metal cover.

Vents should not be sealed in crawl spaces with heating appliances unless adequate provisions for combustion air are provided. Vents may be installed in crawl spaces that have combustion heating systems if there are no vents or if the vents are not properly sized for combustion air. Vents should be non-operable and the client should be informed that the vents are to remain open.

216 Basement Insulation[52]

Basements that show signs of groundwater leakage should not be insulated.

Basement wall insulation should be a minimum R10. Basement walls may be insulated with rigid foam board, batt insulation or spray foam. Insulation should be continuous from the top of the basement wall down to the basement floor.

[52] See SWS 4.1402.2, "Basement Wall Insulation – No Ground Water Leakage"

If space is used only for the service of utilities, such as a cellar with no direct access from the house, it could be treated as a crawl space and insulation shall be separated from the space using a suitable ignition barrier covering or coating according to manufacturer's specifications.

If space is used for storage or occupancy, insulation shall be separated from the space using a thermal barrier material (e.g., 1/2" gypsum wallboard) as specified by applicable building code and manufacturer specifications[53].

All insulation used for basement walls must have, or be covered with a material that has, a flame spread/smoke development index of 25/450 or less when tested in accordance with ASTM E 84 or UL 723.[54]

216-1 Rigid Foam Board Insulation

- Rigid foam board insulation may be installed directly to the basement wall with mechanical fasteners and insulation compatible adhesives (Figure 216-1-1).
- Joints and seams in the insulation should be sealed with sheathing tape to form an air seal.
- A continuous bead of sealant should be used to seal the top and base of the insulation board to the foundation.
- Sealant should also be used to seal the insulation to foundation around windows and doors.
- Vertical edges of the insulation may be routed to accept a 1 inch x 2 inch or 1 inch x

Figure 216-1-1: Rigid foam board basement wall insulation

[53] SWS 4.0402.4i, "Ignition and Thermal Barriers"
[54] SWS 4.0402.4b, "Material Selection"

3 inch furring strip. The furring strips may be used to help secure the insulation to the basement wall with power driven masonry nails. The fire barrier rated material may be attached to the furring strips.

Figure 216-2-1: Vinyl faced fiberglass insulation

- Wood furring strips and gypsum board (if used) shall be held off the basement floor by a minimum 1 inch to prevent capillary action from the basement floor.

216-2 Batt Insulation

- 3 inch or 6 inch thick, vinyl-faced (both sides), metal-building fiberglass insulation sometimes referred to as "basement blanket" or "perimeter wrap" may be used (Figure 216-2-1). The insulation is installed horizontally along the wall and attached to furring strips. Ensure that the vinyl facing meets the flame spread rating.
- Window and door openings should be furred-out. The insulation should be attached and sealed with sheathing tape. Joints between pieces of the insulation should also be sealed with sheathing tape.
- Note that condensation may occur on the basement walls with this technique if the insulation is not well sealed and the basement is subject to high moisture loads.
- Insulation will remain vapor semi-impermeable to the interior when batt insulation is installed.

216-3 Spray Foam Insulation

- One inch of spray foam may be used as an air sealing measure if the foundation material is brick, block or stone. This measure is not acceptable for poured concrete foundations.

Minimum two inch spray foam may be used for insulating foundation walls. Foam shall be applied to a thickness that will obtain a minimum R14.

217 Box Sill Insulation

Penetrations in box sills must be sealed before insulating. Two-part spray foam is recommended for air sealing and insulating the box sill. Rigid foam board may also be used, but the insulation must be foamed in place to provide an air seal. Kraft, foil-faced, vinyl faced and unfaced batt insulation are not permitted (Figure 217-1).

Figure 217-1: Batt insulation is not permitted to be used for box sill insulation

Joist cavities that are parallel to the foundation wall may be sealed and blown with wall insulation unless moisture is present. Stud cavities in balloon framed homes must be air sealed before insulating the box sill.

217-1 Two-Part Spray Foam[55]
Provide minimum 1-inch-thick spray foam (R7) when air sealing. A minimum 2" thick spray foam (R14) shall be used when insulating the box sill.

Figure 217-1-1: Two-part spray foam on box sill

Foam shall make a good seal between the subfloor and box sill and between the box sill and sill plate. Spray foam shall also extend down past the sill plate to foundation wall (Figure 217-1-1). Faced batt insulation may be installed over the two-part spray foam to increase the R-value of the box sill.

[55] SWS 4.0401.1, "SPF Insulation"

If foam is no more than 3 1/4" thick, is between 0.5 and 2.0 lb/ft3 in density and has a flame spread/smoke development index of 25/450 or less when tested in accordance with ASTM E84 or UL 723, no thermal barrier is required[56].

Figure 217-2-1: Rigid foam board sealed in place with 2-part spray foam

If foam is thicker than 3 1/4", does not meet the flame and smoke index, or is not between 0.5 and 2.0 lb/ft3 density, separate foam from the subspace with a suitable thermal barrier covering or coating as indicated in manufacturer's specifications and applicable building code.

217-2 Rigid Foam Insulation[57]

Provide a minimum R10 rigid insulation. Insulation board should be placed firmly against box sill. Insulation should be cut to fit tightly between floor joists and between subfloor and sill plate. Perimeter of insulation should be caulked or foamed to the floor joists, subfloor and sill plate (Figure 217-2-1). Both extruded polystyrene and foil-faced polyisocyanurate may be used.

If foam is no more than 3 1/4" thick and the space is not permanently habitable no thermal barrier is required.[58]

If foam is thicker than 3 1/4", doesn't meet the flame and smoke index, or is of less than 0.5 lb/ft3 density, or the space is permanently habitable, separate foam from the subspace with a

[56] SWS 4.0301.1f, “Ignition and Thermal Barriers”
[57] SWS 4.0401.3, “Rigid Insulation”
[58] SWS 4.0401.3f, “Ignition and Thermal Barriers”

suitable thermal barrier covering or coating as indicated in manufacturer's specifications and applicable building code.

218 Windows

Windows were once thought to be a major air leakage problem. However, the gaps and holes in a home's air barrier are usually much more significant than air leakage around windows and doors. Consequently, window and door air sealing has been deemphasized as part of weatherization. **The following air sealing measures are done when identified with the blower door.**

218-1 Air Sealing[59]

Window air sealing measures should be accomplished using lead-safe weatherization practices (see section 513, "Lead Safe Weatherization Practices").

218-1-1 Caulking

- Remove loose or brittle material before caulking.
- If crack is deeper than 5/16 inch, install backer rod before sealing with caulk. Backing material includes flexible polyurethane, neoprene butyl rod, fiberglass or sponge rubber.
- Use sealants with rated adhesion and joint movement characteristics appropriate for both the window frame and the building materials surrounding the window. Caulking should be applied in a manner that seals the area thoroughly and is neat in appearance.

218-1-2 Weatherstripping[60]

- Large gaps between sash and sill and sash and stops may be weatherstripped. Meeting rails may also be weatherstripped or planed.

[59] SWS 3.0201.1, "Window Air Sealing"
[60] SWS 3.0201.1f, "Weatherstripping"

- Weatherstripping is to be secured by nails or staples, form a permanent airtight seal and not obstruct the operation of the sash.

218-2 Exterior Storm Windows[61]

Metal exterior storm windows shall have the following qualities.

- Frame should have sturdy corners and not tend to rack out-of-square during transport and installation.
- The gasket sealing the glass should surround the glass edge and not merely wedge the glass in place against the metal frame.
- Storm window sashes must fit tightly in their frames.
- The window should be sized correctly and fit well in the opening.
- Storm windows shall be caulked around the frame at time of installation except for weep holes that shall not be sealed. If weep holes are not manufactured into new storm window, weep holes shall be drilled into them.
- Storm window sashes must be removable from indoors.
- Wood storm window inserts shall fit neatly within window frame with the appropriate turn buttons, latches or closing hardware.
- Fixed storm windows shall not restrict the exiting capacity and access required for emergency exits.

218-3 Window Repair

Window repairs associated with high air leakage may be considered as air sealing measures.

All raw wood exposed to the outside must be an exterior grade material and primed on all sides.

[61] SWS 3.0201.8, "Exterior Operable Storm Window Installation"

218-3-1 Glass Replacement[62]

- Glass should be secured with glazing points (2 inches from each corner and not less than 8 inches apart) and puttied with latex or oil based glazing compound or sealed with plastic or vinyl glazing strips.
- Glass set in metal frames should have metal-glazing clips no more than 12 inches apart and within 4 inches of each corner and the joint between the two surfaces puttied.
- Glass over 25 inches in either dimension should not be less than "B" grade double strength.
- Safety glass is required in windows located within 12 inches of a door when the bottom edge is less than 60 inches above the floor or if panes are larger than 9 ft^2 when the bottom edge is less than 18 inches above the floor.

218-3-2 Re-glazing

- Window glazing compound should only be replaced if the existing glazing is deteriorated to the degree that the window glass is in jeopardy of falling out of the sash.
- Silicone caulk may not be used in place of a glazing compound.
- Glazing compound is to be tooled smooth to form a concave surface and be neat in appearance.

218-3-3 Stops[63]

Window stops should be installed in such a way as to ensure a tight seal between the jamb, sash and stop. Ensure that window operates smoothly following stop adjustment. Wood exposed to the weather must be primed on all sides.

- Wood installed should be similar in size and shape to other existing window stops in the house.
- Installed window stop is to be planed or sanded smooth.

[62] SWS 3.0201.4, "Glass Replacement"
[63] SWS 3.0201.1e, "Sash Stops"

- New stop is to be painted or varnished to blend with current trim.
- Corners of installed materials are to be mitered or coped.
- If matching window stop is not available, then all stops on the window are to be replaced.

218-3-4 Sills[64]

Factory made sills or sills made from copper treated lumber must be used for window sill replacements. CCA (chromate-copper-arsenate) lumber is not to be used. Wood exposed to the weather must be primed on all sides.

- Sill is to be beveled flush with the interior wall.
- Sill shall be the same distance from the house as other window sills.
- Sill shall be installed at the same angle as other windows sills on the home.
- All seams shall be caulked after installation.
- Sills shall be painted to match the rest of the windows on the home.

218-3-5 Sash Locks[65]

The meeting rails of the upper and lower sashes are to be flush.

- Blocks under the sash lock or chiseling out part of the sash to recess the lock is not acceptable.
- Sash locks are to be centered on the check rails.
- Cam-type sash locks may be used. If used, one must be installed at each side rail of the bottom sash.

218-3-6 Sash Replacement[66]

New sashes are to be installed in a manner as to allow the lower sash to stay in an open position when raised and down when closed. The client should be able to open and close sash easily.

[64] SWS 3.0201.3, "Window Sill Replacement"
[65] SWS 3.0201.1g, "Sash Locks"
[66] SWS 3.0201.2, "Window Sash Replacement"

- The lower sash must have the same bevel on the bottom rail as that of the sill.
- Sashes are to be painted or varnished to match the existing sashes.
- Glazing compound and glazier points shall be used when replacing glass.
- Replace missing or severely deteriorated window frame components, such as stops, jambs or sills.

218-4 Window Replacement[67]

Replacement windows shall be ENERGY STAR rated with a U-value no higher than 0.24.

True mobile home replacement windows shall have a U-value no higher than 0.36 and need not be ENERGY STAR rated. Replacement windows meant for site-built homes but used in mobile homes shall have a U-value no higher than 0.24 and be ENERGY STAR rated.

Figure 218-4-1: NFRC label

Replacement windows for multi-family buildings that are three stories or under shall meet the requirements for single-family homes. Replacement window U-values in multi-family buildings that are greater than three stories shall have a U-value no higher than 0.35.

Replacement windows shall have U-values rated by the National Fenestration Rating Council (NFRC) (Figure 218-4-1).

At least one NFRC label must be removed by the contractor and submitted with the contractor's invoice upon completion of the

[67] SWS 3.0201.9, "Window Replacement"

home for verification. The remaining NFRC labels shall be left on the window for removal by the final inspector.

Window replacements must be ENERGY STAR rated and must obtain an SIR at or above 1.00 to use DOE funds. If window/door replacement has SIR < 1.0 they can be replaced with HHS or State funds as long as the Current Work Order SIR remains at 1.0 or above.

219 Doors

Doors have a small surface area and their air leakage is more of a comfort problem than a serious energy problem most of the time. **Door replacements must be ENERGY STAR rated and must obtain an SIR at or above 1.00 to use DOE funds. If window/door replacement has SIR < 1.0 they can be replaced with HHS or State funds as long as the Current Work Order SIR remains at 1.0 or above.**

219-1 Air Sealing[68]

The following air sealing measures are done when identified with the blower door:

219-1-1 Weatherstripping[69]

Door hardware should be tightened and door adjusted to close snugly against its stops before weatherstripping is applied. Door should close without having to use excessive force following weatherstrip installation. (Figure 219-1-1).

Figure 219-1-1: Door weatherstripping, threshold and sweep

[68] SWS 3.0202.1, "Door Air Sealing"
[69] SWS 3.0202.1f, "Weatherstripping"

Weatherstrip is to consist of a semi-rigid strip with vinyl or neoprene flap. A bulb type weatherstrip is also acceptable if the bulb is made of siliconized rubber and a minimum of ¼ inch diameter. A third type that can be used is a tough vinyl tear-resistant skinned material enclosing cellular foam.

- New weatherstrip must form a tight seal, be neat in appearance and be fastened in such a way as to prevent buckling or gaps.
- All existing weatherstrip is to be removed from the door if installing new.
- Door trimming and adjustments, including hinge tightening and strike plate adjustments may be necessary and must be done before installing weatherstrip.
- A small bead of caulk is to be applied to make the weatherstrip and the door stop airtight.
- Nails or other fasteners are to be made of a non-rust material.

219-1-2 Thresholds

Thresholds and door sweeps shall be installed to prevent infiltration while not preventing the door from operating properly.

- Thresholds are to be set entirely on the sill or a continuous shim from end to end so no gap exists between the threshold and doorsill.
- Thresholds are to fit snugly between the jambs and fastened to the sill and the floor with screws.
- Thresholds are to be caulked on both the interior and exterior to form a tight seal with the doorsill.
- All unfinished wood installed is to be painted or varnished to a smooth finish.

219-1-3 Sweeps

Sweep installation is to be neat in appearance, form an airtight seal and not interfere with the operation of the door.

- Sweeps are to be a metal strip with a vinyl or neoprene insert, or a brush type installed with screws on the interior side of the door.
- Sweeps are to be cut to the same width as the door.

- Sweep shall be secured within 2 inches of the door edge on each end.
- Sweeps shall have a threshold or carpet bar to seal against.

219-2 Door Replacement[70]

Pre-hung replacement doors without glazing must be ENERGY STAR rated with a U-value no higher than 0.17.

Replacement doors with glazing must have a U-value no higher than 0.26. Replacement sliding glass doors must have a U-value no higher than 0.26.

Wood slab doors do not have to meet this requirement when a pre-hung door cannot be used. The ENERGY STAR rating does not apply to mobile home replacement doors.

- Whenever possible, 1-3/4 inch thick doors are to be used.
- All new wood doors are to operate smoothly, be sanded and be painted or varnished to a smooth water repellent finish.
- Doors shall have a 5° bevel cut on the bottom to form an airtight seal between the bottom of the door and the gasket of the threshold.
- New 1-3/4 inch doors shall receive three new 4 inch x 4 inch butt hinges; 1-3/8 inch doors shall have three new 3 ½ inch x 3 ½ inch butt hinges that are mortised into the door and jamb.
- When installing a new door and jamb, the hinges are to be placed at 7 inches from the top of the door, 11 inches from the bottom of the door and the third hinge centered between the top and bottom hinge.
- New door shall have a new door lock installed (whenever possible a 2-3/4 inch backset should be used unless using a pre-hung door that is pre-drilled for a 2-3/8 inch lockset). The client is to receive all keys - minimum two keys per lockset. If possible, multiple locks should be keyed alike.

[70] SWS 3.0202.2, "Door Replacement"

219-3 Pre-Hung Replacement Doors

If a pre-hung door is needed, pre-hung replacement doors must meet the current ENERGY STAR criteria.

- All door jambs must receive at a minimum, shims behind each hinge and lockset and any other area needed to support the door jamb.
- New jambs must be trimmed out to match existing interior and exterior trim.
- Galvanized casement nails must be used, counter sunk and filled.
- All doorsills installed must be flush with the floor of the house.

219-4 Door Repair

All repair work must be within excepted carpenter standards. All replacement materials are to be of the type and size already existing on the door. Door repairs are considered “incidental repairs”.

All raw wood exposed to the outside must be an exterior grade material and primed on all sides.

219-4-1 Jambs

Remove damaged or deteriorated portion of the jamb and replace with matching materials, butting uniformly to adjacent members. All work is to be neat and form a tight seal.

- All loose sub members and casing is to be secured and all wood installed is to be finish grade or factory made jamb material.
- All installed lumber is to be planed or sanded smooth and painted or varnished to a smooth finish to match existing.
- Hinges are to be tightened or re-set.
- Casing used is to match the existing casing on the house. If matching casing is not available, then all of the casing on the door is to be replaced. Wood is to be installed flush with the wall to insure a tight fit.

- Any damaged interior wall is to be repaired with like materials.
- Strike plate shall be tightened or re-set to hold the door flush with the doorstop.
- Strike plate is to be mortised into the jamb.

219-4-2 Stops[71]

Reposition stops if necessary. Seal gaps between the stop and jamb with caulk.

- Wood used for door stop is to be manufactured as doorstop.
- If a section of the stop is missing or must be replaced and the stop cannot be matched to the existing stop, then the entire stop on that jamb is to be replaced.
- Joints are to be mitered or coped to form a tight corner joint.
- Wood installed is to be sanded smooth and painted or varnished to a smooth finish and approximately match the existing wood.

219-4-3 Locksets/Strikeplates[72]

Replace missing or inoperable lock sets; or reposition the lock set/strikeplate; or install a modernization kit so that the door can be held in a tightly closed position.

- Lock set is to be installed between 36 inches and 39 inches from the floor with a 2-3/4 inch backset whenever possible.
- Cover plates are to completely cover the hole drilled for the lockset cylinder.
- Faceplate and strike plates are to be mortised flushed with the wood of the door and jamb. Screws are to be installed straight and be flush with the face and strike plates.
- Strike plate must be installed in a manner as to allow the door to latch easily but with minimum play between the door and stop.

219-5 Storm Doors

Storm door installation or replacement is not allowed.

[71] SWS 3.0202.1g, “Door Stop”
[72] SWS 3.0202.1e, “Handle/Lockset”

220 Baseload

220-1 Light Emitting Diodes (LEDs)[73]

LED lamps must be ENERGY STAR rated.

LED lighting products use light emitting diodes to produce light very efficiently. An electrical current passes through a semiconductor material which illuminates tiny light sources called LEDs. LEDs are now being incorporated into bulbs and fixtures for general lighting applications. LED lamps that have earned the current ENERGY STAR are subject to very specific requirements designed to replicate the experience of a standard incandescent lamp, so they can be used for a wide variety of applications. LED light fixtures and lights contain no hazardous chemicals and fully comply with the Restriction of Hazardous Substances directive, which limits the use of lead, mercury, and four other hazardous materials in electronics.

Refer to table 200-1 for selecting appropriate LED lamps when replacing CFLs and incandescent lamps.

Table 200-1

Equivalent Light Output: LED to CFL to Incandescent

Light Output	LEDs	CFLs	Incandescents
Lumens	Watts	Watts	Watts
450	4 - 5	8 - 12	40
300 - 900	6 - 8	13 - 18	60
1100 - 1300	9 - 13	18 - 22	75 - 100
1600 - 1800	16 - 20	23 - 30	100
2600 - 2800	25 - 28	30 - 55	150
Light bulb projected lifespan	50,000 hours	10,000 hours	1,200 hours

[73] SWS 7.0103.1, "Lighting Replacement"

- LED lamps should be listed as "soft white" (or have a Kelvin temperature of 2700º to 3000ºK) to match the light quality of incandescent.
- Standard LED lamps should never be used in fixtures controlled with standard dimmable switches. Dimmable switches compatible with the LED lamps should be used in these types of fixtures.
- Exterior LEDS must be rated for outdoor use.
- **CFLs removed from clients' homes must be recycled and cannot be disposed of in landfills.**

220-2 Replacement Refrigerators and Freezers[74]

Replacement refrigerators and freezers shall be ENERGY STAR rated (Figure 220-2-1). At a minimum, replacement models must meet Federal National Appliance Energy Conservation Act (NAECA) ratings. All replacement refrigerators must meet the UL-250 standard. Only refrigerators located within the thermal boundary of the home are eligible for replacement.

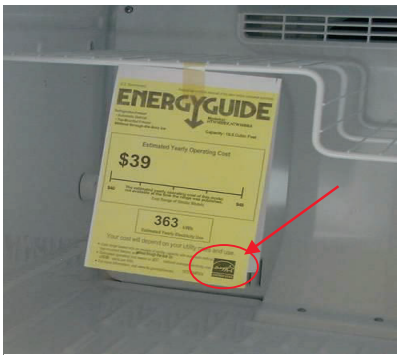


Figure 220-2-1: Replacement refrigerators and freezers must be ENERGY STAR rated

All new replacement refrigerators and freezers must have a fifteen-year expected life. The warranty on all replacement refrigerators and freezers must meet or exceed a one-year full warranty on parts and labor.

Replacement refrigerators shall have the following features:

- Freezer on top
- Auto defrost

[74] SWS 7.0101.1, "Refrigerator and Freezer Replacement"

- Standard shelving
- No ice maker
- No water dispenser
- Reversible doors
- Easy-roll wheels
- Up-front controls

Replacement freezers must be ENERGY STAR rated. Replacement freezers should be no larger than the replacement unit. If possible, chest style freezers should be installed as they are more energy efficient than upright freezers.

The contractor shall:[75]

- deliver and install the new refrigerator or freezer,
- level the unit to ensure proper operation,
- ensure that door hinges are on the appropriate side,
- instruct the customer on refrigerator or freezer operation,
- deliver warranties and operating manuals to the customer,
- set temperature controls appropriately,
- remove all packing materials from the client's home,
- remove the old refrigerator or freezer from the client's home, and
- properly dispose of all replaced refrigerators and freezers.

220-2-1 Disposal[76]

All refrigerators and freezers that are replaced must be removed from clients' homes upon delivery of the replacement units and properly disposed of in accordance with The Clean Air Act, USC Title 42, Section 7671g. This Act makes it unlawful for any person to dispose of refrigerants in a manner in which they will be allowed to enter the environment.

[75] From "Incorporating Refrigerator Replacement into the Weatherization Assistance Program", USDOE, 2001
[76] SWS 7.0101.1e, "Disposal"

All refrigerators and freezers removed from clients' homes must be taken to a recycling facility. Contractors must obtain a certificate or receipt indicating the appliance has been accepted by the recycling facility. A copy of the certificate or receipt indicating the appliance has been accepted by the recycling facility must be provided to the local weatherization agency and be placed in the client file for each refrigerator/freezer replacement. Contact the Weatherization Agency regarding nearest recycling facility or process.

Refrigerators and freezers removed from clients' homes may not be sold, given away or returned to service in any manner. Appliances infested with pests will be enclosed before removal.

220-3 Low Flow Showerheads[77]

Low flow showerheads shall have a maximum flow rate of 2.0 gallons per minute (gpm) and shall have the *WaterSense* label (Figure 2203-1).

If multiple heads are provided in a shower stall, the total flow rate may not exceed 2.5 GPM.

Select features that meet any special needs of the occupant (e.g., shut off, swivel, handheld showers).

New showerheads and necessary adapters shall be installed according to manufacturer's instructions. Threads shall be properly sealed with plumbers tape to prevent leaks. Any damage done to the house during installation will be repaired. If needed, shower diverter will be repaired or replaced.

[77] SWS 7.0201.1, "Low-Flow Devices"

220-4 Aerators

Aerators shall have a maximum flow rate of 1.5 gpm and shall have the *WaterSense* label (Figure 220-3-1).

220-5 Showerhead and Aerator Summary

Warranty information, operation manuals, and installer contact information will be provided to the occupant for both low flow showerheads and aerators.

Note that IHWAP's maximum flow rate standards for both low-flow shower heads and faucet aerators exceed those outlined in the SWS. IHWAP standards will be followed.

Figure 220-3-1: *WaterSense* label

300 – Mechanical Standards

311 Combustion Efficiency and Venting

This section specifies maintenance, repair and efficiency improvements to the fire side of the heating appliance. Procedures outlined here require training, skill, experience and knowledge of the health and safety hazards associated with combustion heating systems.

Definitions:

Category I Appliance: An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent.[1]

Natural Draft Furnace: A natural draft furnace (or atmospheric furnace) is a heating system that relies on buoyancy—hot air rising—rather than mechanical fans to move combustion gases up a chimney. Typically, 70% efficient.

Fan-Induced Furnace: A fan-assisted natural draft furnace (often referred to as an induced draft furnace) is a mid-efficiency heating system that uses a small mechanical fan, known as a draft inducer, to actively pull combustion gases through the heat exchanger and push them out through the venting system. While a fan assists the initial venting process, it is considered "natural draft" because the flue gases are still hot enough to rise on their own, typically venting into a traditional chimney or B-vent, rather than using a high-powered, sealed, or pressurized venting system. Typically, 80% efficient.

[1]American National Standards Institute (ANSI) z223.1/National Fire Protection Association (NFPA) 54 (NFPA 2012a)

311-1 Natural Gas and Propane

311-1-1 Gas-burner Inspection, Testing and Correction

Perform the following inspection procedures and maintenance practices on all gas-fired furnaces, boilers, water heaters and vented space heaters.

Refer to Table 300-1 for acceptable combustion test analysis values.

Figure 311-1-1-1: Evidence of flame roll-out

1. Inspect the burners for dust, debris, misalignment and other flame-interference problems. Look for soot, burned wires and other evidence of flame roll-out (Figure 311-1-1-1).
2. Clean, vacuum and adjust burners (Figure 311-1-1-2).
3. Clean and adjust thermostat and check anticipator setting.
4. Determine that pilot is burning (if equipped) and that main burner ignition is satisfactory. Test pilot-safety control for complete gas valve shutoff when pilot is extinguished.
    - Install new thermocouple (if an intermittent ignition device, or IID, is not present or not being installed).
    - Adjust pilot flame so the hot tip of the thermocouple is enveloped by the flame.
5. Observe flame characteristics if soot, CO, or other combustion problems are evident.
    - Remove causes of CO and soot, such as closed or blocked primary air intake, over-firing and flame impingement.

Figure 311-1-1-2: Clean burners with stiff brush

6. Check venting system for proper size, pitch and connection by referencing NFPA 54 (Figure 311-1-1-3).
7. Check venting system for obstructions, blockages or signs of condensation (Figure 311-1-1-4).
8. Check high limit control for proper operation.
9. Measure gas input (see Table 300-2)
    - Adjust gas input if burners are over-fired or under-fired. Adjust input by adjusting gas pressure to between 3.3" and 3.5" water column (w.c.) for natural gas and 10 " w.c. to 11" w.c. for propane or replace the burner orifices.

Figure 311-1-1-3: Ensure that vent is properly connected

10. Conduct Combustion Safety Test (see section 312, "Combustion Safety Testing"). There are three parts to this test.
    1. *Determine worst case depressurization condition* (see section 3121); the worst case condition for a Combustion Appliance Zone (CAZ) is established; in other words, the greatest magnitude of negative pressure in the CAZ under which the combustion appliances might have to operate is determined. **The following tests are conducted under these conditions.**

Figure 311-1-1-4: Check vent for condensation problems

2. *Spillage* (see section 312-2)[2] - the spillage test only applies to Category I appliances.
   Category I Water Heaters -
   Spillage must cease (water heater begins drafting) within two minutes. If water heater begins drafting within two minutes, the water heater passes the test.
   Category I Furnaces - Warm Vent (when furnace thermostat is <u>on</u> heat and/or it is common-vented with a water heater)
   Spillage must cease (furnace begins drafting) within two minutes. If furnace begins drafting within two minutes, the furnace passes the test.
   Category I Furnaces - Cold Vent (when furnace thermostat is <u>not on</u> heat AND the furnace is NOT common-vented with a water heater)
   Spillage must cease (furnace begins drafting) within five minutes. If furnace begins drafting within five minutes, the furnace passes the test.
   If the Category I appliance is common vented (multiple combustion appliances sharing chimney and/or venting system) to an induced draft appliance the water heater diverter should be checked for spillage after firing the common vented induced draft appliance and spillage must stop within 2 minutes.
3. *Carbon Monoxide* (see section 312-3); carbon monoxide (CO) air free readings shall not exceed the thresholds in Table 300-3.

11. Conduct steady state efficiency test (see section 313, "Steady State Efficiency Test").

[2] ANSI/BPI-1200-S-2017, "Standard Practice for Basic Analysis of Buildings", sections 7.9.2 and 7.9.3

Acceptable Combustion Test Analysis Measurements

Table 300-1

Heating Unit Type	*Oxygen (O_2)*	*Net Stack Temp.*	*Smoke Test*	*Co Air Free PPM max*
Gas				
Cat. 1 Natural Draft Gas Furnace 70%	4 - 9%	300-600* F	NA	400 ppm af
Cat. 1 Natural Draft Fan-assisted Gas Furnace 80%	4 - 9%	300-480*F	NA	400 ppm af
Cat. 4- High Efficiency Condensing Gas Furnace 90%+	5% - 9% See PMI	<140* See PMI	NA	400 ppm af
Cat. 1 Natural Draft Gas Water Heater	4- 9%	300-600*F	NA	200 ppm af
Cat. 4- Power Vented High Efficiency Gas Water Heater	4- 9%	<140*F See PMI	NA	200 ppm af
Cat. 1 Natural Draft Gas Boiler	4 - 9%	300-550*F	NA	400 ppm af
Cat. 4 High Efficiency Condensing Gas Boiler 90%+	4- 9%	<140*F See PMI	NA	400 ppm af
Oil (No. 1 & 2)				
Oil gun burner	4 - 9%	325-600° F	1 or less	400 ppm af
Flame Retention Burner	4 - 7%	325-600° F	1 or less	400 ppm af

Stove/Oven Gas 225 PPM As Read

Clocking the Gas Meter

Table 300-2

Seconds for One Revolution on the Dial	½ ft³	1 ft³	2 ft³	Seconds for One Revolution on the Dial	½ ft³	1 ft³	2 ft³
10	180	360	720	40	45	90	180
11	164	327	766	41	44	88	176
12	150	300	600	42	43	84	172
13	138	277	555	43	42	84	167
14	129	257	514	44	41	82	164
15	120	240	480	45	40	80	160
16	112	225	450	46	39	78	157
17	106	212	424	47	38	77	153
18	100	200	400	48	37	75	150
19	95	189	379	49	37	73	147
20	90	180	360	50	36	72	144
21	86	171	343	51	35	71	141
22	82	164	327	52	35	69	138
23	78	157	313	53	34	68	136
24	75	150	300	54	33	67	133
25	72	144	288	55	33	65	131
26	69	138	277	56	32	64	129
27	67	133	267	57	32	63	126
28	64	129	257	58	31	62	124
29	62	124	248	59	30	61	122
30	60	120	240	60	30	60	120
31	58	116	232	62	29	58	116
32	56	113	225	64	29	56	112
33	55	109	218	66	29	54	109
34	53	106	212	68	28	53	106
35	51	100	206	70	26	51	103
36	50	100	200	72	25	50	100
37	49	97	195	74	24	48	97
38	47	95	189	76	24	47	95
39	46	92	185	78	23	46	92

12. Clocking the meter - Using a stopwatch, measure the number of seconds for either the ½ ft^3 or the 1 ft^3 dial to make one complete revolution. Timing cycle should be a minimum of 30 seconds, increase timing by larger volume dial or multiple revolutions if necessary. Read the corresponding input rate in 1,000 of Btus/ft^3.

311-1-2 Leak-testing Gas Piping

Natural gas and propane piping systems may have leaks at their joints and valves. Assessors, mechanical contractors and final inspectors must perform a gas leakage test on all gas supply lines, couplings, joints and connections with an electronic combustible-gas detector, often called a gas sniffer. The entire gas line shall be checked with the detector at a rate of 1inch per second with the tip above the line for natural gas and below for LP gas. The

circumference of each joint shall be checked with the detector at a rate of 1" per second.

- All valves and joints shall be checked with the gas detector.
- Leaks shall be confirmed using a non-corrosive bubbling liquid designed for finding gas leaks.

All gas leaks and damaged gas lines must be repaired.

311-1-3 Combustion Air[3]
Calculate combustion air needs in conformance with the applicable code (i.e., *NFPA* 54, *IFGC*, or *NFPA* 31) and manufacturer requirements.

In instances where conflicts occur between the code and the manufacturer's installation instructions, the more restrictive provisions shall apply (i.e., more air rather than less).

The minimum required volume is 50 cubic feet per 1,000 *BTU*/h of input, except that where the air infiltration rate is known to be less than 0.40 air changes per hour (ACH), then use alternate calculation from *IFGC*[4].

311-2 Electric Heating Systems
The following measures shall be done on all electric furnaces.

- Inspect all electrical connections for signs of overheating.
- Check and clean thermostat.
- Check, clean and oil blower motor if applicable.
- Clean all filters. Replace if necessary.
- Vacuum and clean housing around electric elements, if applicable.
- Vacuum and clean all fins on electric-baseboard systems, if applicable.
- Verify that all heating elements and controls are operational.

[3] SWS 5.0502.1a, "Design"
[4] See *International Fuel Gas Code*, sections 304.5.1 and 304.5.2.

311-3 Wood Burner Safety

Wood stoves (Figure 311-3-1) should be visibly inspected for the following conditions:

Figure 311-3-1: Wood burner

- Inspect stove, vent connector and chimney for correct clearances from combustible materials as listed in NFPA 211. Ensure that stove is sitting on a noncombustible floor.
- Inspect vent connector and chimney for leaks (these will be sealed with a high-temperature sealant designed for use with a metal or masonry chimney).
- Inspect the house for soot on seldom-cleaned horizontal surfaces. If soot is present, the gasket on the wood stove door may have to be replaced or sealed.
- Inspect chimney and vent connector for creosote build-up and clean chimney if significant creosote build-up exists.
- Inspect damper and/or combustion air intake if present. Ensure that it is not blocked (Figure 311-3-2).
- Check and replace fire door gaskets if applicable.
- Check catalytic converter for repair or replacement if applicable.

Figure 311-3-2: Dirty combustion air intake to wood stove that needs to be cleaned

312 Combustion Safety Testing

Assessors, mechanical contractors and final inspectors are required to do Combustion Safety Testing. Mechanical contractors are required to complete these tests following completion of work each day as well as at job completion.

Architectural contractors and crews are required to do a Spillage Test-Out (see section 117, "Spillage Test-Out") at the end of each work day.

Figure 312-1: Personal CO monitor

Assessors, mechanical contractors and final inspectors are required to wear personal CO monitors while conducting combustion safety testing (Figure 312-1). See section 502, "Ambient Carbon Monoxide Monitoring", for additional information.

If ambient CO levels exceed 9 ppm, see section 502-2, "Indoor Ambient CO Action Levels", for additional guidance.[5]

The purpose of all combustion safety testing is to ensure that all combustion appliances in a home vent properly.

Figure 312-2: Combustion appliance zone: note presence of grille in return air duct that can cause depressurization of the water heater

Proper venting is essential to the operation, efficiency, safety and durability of combustion appliances. Air tightening the home can weaken draft and weatherization work can reduce the heater's operating time, resulting in a cooler flue.

[5] ANSI/BPI-1200-S-2017, "Standard Practice for Basic Analysis of Buildings", section 7.3.3

Tightening a home can also reduce air to combustion appliances resulting in backdrafting and/or "lean burns" that produce carbon monoxide (Figure 312-2).

There are three parts to this test.

1. *Determining worst case depressurization condition* (312-1); the worst case condition for a Combustion Appliance Zone (CAZ) is established; in other words, the greatest magnitude of negative pressure in the CAZ under which the combustion appliances might have to operate is determined. **The following tests are conducted under these conditions.**
2. *Spillage* (see section 312-2)[6] - the spillage test only applies to Category I appliances.

   Category I Water Heaters -

   Spillage must cease (water heater begins drafting) within two minutes. If water heater begins drafting within two minutes, the water heater passes the test.

   Category I Furnaces - Warm Vent (when furnace thermostat is <u>on</u> heat and/or it is common-vented with a water heater)

   Spillage must cease (furnace begins drafting) within two minutes. If furnace begins drafting within two minutes, the furnace passes the test.

   Category I Furnaces - Cold Vent (when furnace thermostat is <u>not on</u> heat AND the furnace is NOT common-vented with a water heater)

   Spillage must cease (furnace begins drafting) within five minutes. If furnace begins drafting within five minutes, the furnace passes the test.

If the Category I appliance is common vented (multiple combustion appliances sharing chimney and/or venting system) to an induced draft appliance the water heater diverter should

[6] ANSI/BPI-1200-S-2017, "Standard Practice for Basic Analysis of Buildings", sections 7.9.2 and 7.9.3

be checked for spillage after firing the common vented induced draft appliance. With the water heater still operating, fire the induced draft appliance and check for spillage at the water heater. Spillage must stop within 2 minutes (Figure 312-3). The appliance with the lowest BTU input should be fired first – this is usually the water heater.

Figure 312-3: Checking for spillage at the water heater after firing the furnace

3. *Carbon Monoxide* (see section 312-3); carbon monoxide (CO) air free readings shall not exceed the thresholds in Table 300-3.

If a house contains more than one CAZ, combustion safety testing must be performed for each area. Additionally, if more than one vented combustion appliance is in a CAZ, each must be tested for safe operation under worst case conditions. Combustion appliances include furnaces, boilers, water heaters and vented space heaters.

Potential solutions for Combustion Safety Testing failures are presented in section 312-5.

312-1 Worst Case Depressurization

"Worst case" is defined as the configuration of the house that results in the greatest negative pressure in the vented combustion appliance or fireplace zone (CAZ).

Determining the worst case depressurization condition (WCD) must be done in all homes. The following are *exceptions* to this requirement:

1. All vented combustion appliances are sealed combustion (direct vent) or power vented.
2. CAZ testing is not required for fireplaces or wood stoves.
3. If the house or mobile home is all-electric with no combustion appliances, woodstoves or fireplaces.
4. If the home has a boiler and has no exhaust equipment, including clothes dryers, vented bath and kitchen fans, vented central vacuum systems, fireplaces, woodstoves, etc.
5. If the CAZ is located outside the thermal boundary and there are no return ducts in the CAZ. However, always perform this test if the CAZ is in a vented crawl space or a basement deemed to be outside the thermal boundary or a tuck-under or attached garage.

312-1-1 Manometer Set-Up

Set up the digital manometer as follows to measure pressure difference of a combustion zone with reference to the outside.

- Connect a hose from the “reference” tap on the digital manometer to the exterior of the home (Figure 312-1-1-1).
- Connect a hose from the “input” tap on the digital manometer to within two feet of the combustion appliance. This hose is not needed if measurements are taken while standing in the CAZ as shown with the DG700 manometer in Figure 312-1-1-1.

Figure 312-1-1-1 DG700, DG1000 & DM32 manometers set-up for WCD test. Note that hose to CAZ not necessary if readings are being taken in the CAZ

Refer to the *Worst Case Depressurization and Spillage Testing* job aid if needed. Measurements made with the house in the worst case depressurization condition will likely be quite small. Taking these readings on a windy day can be difficult. Care should be taken to protect the tip of the exterior hose from the wind. One method for countering the effects of the wind is by placing the end of hose in the middle of the home, against the foundation, on the leeward side of a home.

312-1-2 House Set-Up

House must be set-up for winter conditions.

- All windows and exterior doors should be closed.
- Close all interior doors except doors to rooms with an exhaust fan and rooms with a ducted return.
- Close CAZ door.
- Turn off all exhaust fans (including ASHRAE fan if present) and clothes dryer.
- Remove, clean and replace lint filter from dryer.
- If dirty, remove filter from furnace. Otherwise, leave filter in place. Do not remove filter cap if present.
- Close supply air registers if present in the CAZ.
- Close damper on fireplace if present.
- Set water heater to pilot and ensure that other combustion appliances are turned-off.

312-1-3 Determining Worst Case Depressurization Condition

1. Set the adjusted baseline with house set-up as described above. 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.

2. Turn on clothes dryer and all exhaust fans in house. If ASHRAE fan has been installed, set to operate at its maximum CFM exhaust rate. Turn on central vacuum

cleaner if present. Do not turn on whole house fans[7]. Record pressure difference (**P1**).

3. Turn on the furnace air handler, leaving on all the exhaust fans. If cooling is present, run the air handler on high speed. Record pressure difference (**P2**).
   - If the pressure becomes more negative, leave air hander on for P3 measurement.
   - If the pressure becomes more positive, turn off air handler for P3 measurement.

4. Open CAZ door. Record the pressure difference **(P3)**.
   - If the pressure becomes more negative, leave CAZ door open.
   - If the pressure becomes more positive, close CAZ door.

5. Compare the three readings. The reading with the highest negative number is the worst case. The house shall remain in this configuration for the spillage test and for measuring CO. Note that this CAZ procedure must be repeated for each CAZ in the home.

312-2 Spillage Test[8] (Category I appliances only)
Fire the appliance with the smallest Btu capacity first and test for spillage at the draft diverter with a smoke pencil.

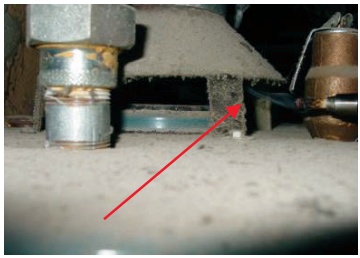


Figure 312-2-1: Appliance passes spillage test

[7] 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.
[8] ANSI/BPI-1200-S-2017, "Standard Practice for Basic Analysis of Buildings", sections 7.9.2 and 7.9.3

Category I Water Heaters -

Spillage must cease (water heater begins drafting) within two minutes. If water heater begins drafting within two minutes, the water heater passes the test (Figure 312-2-1).

Category I Furnaces - Warm Vent (when furnace thermostat is on heat and/or it is common-vented with a water heater) –

Spillage must cease (furnace begins drafting) within two minutes. If furnace begins drafting within two minutes, the furnace passes the test.

Category I Furnaces - Cold Vent (when furnace thermostat is not on heat AND the furnace is NOT common-vented with a water heater) –

Spillage must cease (furnace begins drafting) within five minutes. If furnace begins drafting within five minutes, the furnace passes the test.

Induced draft appliances must also be checked for spillage if they are combined with a Category I appliance in a common vented system. The induced draft appliance must be checked for spillage at the diverter of the Category I appliance. The appliances must be checked for spillage in order of appliance input rating. Spillage must stop within 2 minutes.

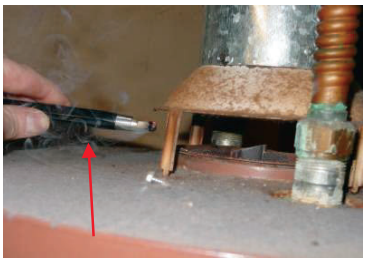


Figure 312-2-2: Appliance fails spillage test

If two appliances share a common vent following a wye connection, ensure that the common vent is properly sized for both appliances. Spillage may result if the common vent is undersized. See NFPA 54, Tables 3 and 4, for guidance.

If appliance fails spillage test (Figure 312-2-2), turn-off appliance and open window if possible. Check for blocked flue or chimney. If blockage is found and removed, repeat spillage test. Also see section 312-4, “Solutions to Combustion Safety Testing Failures”.

Any appliance that fails the spillage test may not be left in that condition. Turn off appliance and the exhaust fans and open all the interior doors. Allow the vent to cool and then re-test for spillage and CO under natural conditions (see section 312-3, "Carbon Monoxide Testing"). Operating the blower door will help cool the combustion gases. Measure the net change in pressure from worst case to natural in the CAZ to confirm worst case depressurization.

See section 312-4, "Solutions to Combustion Safety Testing Failures", for potential actions for appliances that fail the spillage test.

312-3 Carbon Monoxide (CO) Testing

- CO testing of all combustion appliances is required.
- CO air free readings are to be taken and compared to the values in Table 300-3.
- CO air free readings are not to exceed those in Table 300-3.
- CO readings are to be taken after 5 minutes of main burner operation.
- Appliances with CO emissions higher than the threshold limits should be cleaned and tuned and tested for CO emissions again. Contact Weatherization Agency if high CO emission problem cannot be corrected.
- If the CO thresholds are exceeded and ambient CO levels do not exceed 70 ppm (see section 502-2, "Indoor Ambient CO Action Levels"), work in the home may continue.

CO Threshold Limits for Combustion Appliances[9]

Table 300-3

Appliance	Threshold Limit
Furnace	400 ppm air free
Water Heater	200 ppm air free
Boiler	400 ppm air free
Vented Space Heater	400 ppm air free

CO readings are often taken at the same location in the vent connector as combustion efficiency readings (see section 313, "Steady State Efficiency Test").

Category I Appliances

- Readings must be taken just before the emissions are diluted by room air at the draft diverter (Figure 312-3-1). Drilling a hole is often not necessary.
- Where the appliance has multiple burners and cells, each cell of the heat-exchanger must be tested separately. The highest CO reading (not the average) should be recorded and used when deciding the appropriate course of action.

Figure 312-3-1: CO reading taken for water heater before dilution air

Fan Induced Appliances

- Drill test hole about 1 foot away from where the gases exit the appliance.
- Hole should be in a straight piece of vent pipe away from turns (inducer fans and turns can cause turbulence and make stable readings difficult to obtain).

[9] ANSI/BPI-1200-S-2017, "Standard Practice for Basic Analysis of Buildings", Table 1

- See section 313-2, “Fan Induced Appliances”, for sealing test holes.

Direct Vent Sealed Combustion Appliances (condensing)

- The recommended testing point for condensing appliances is to sample the gasses at the outside of the house by inserting the test probe into the PVC vent pipe at least 6 inches.
- If testing cannot be done on the exterior because the vent pipe is not accessible, testing can be done by drilling the PVC vent pipe near the furnace. Test hole must be drilled and tapped with threads for 1/8” pipe threads and then sealed with a plastic pipe plug and sealant. Proper technique and equipment must be used to seal this pipe as it is under positive pressure and improper sealing will allow vent gasses to enter the house.
- Test holes can be drilled in vertical pipes or the top half of horizontal pipes.

312-4 Solutions to Combustion Safety Testing Failures

The following are potential solutions for spillage failures.

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 the problem.

Figure 312-4-1: Repair duct system

c. Properly seal return duct leakage in the CAZ (Figure 312-4-1) or supply air duct leakage outside the thermal boundary.
d. Increase the CAZ air volume by connecting the CAZ to other areas within the conditioned volume of the house.

e. Increase the CAZ air volume by connecting the CAZ to the outdoors (Figure 312-4-2).
f. Install a manufacturers' outdoor air kit for the failed appliances. This is an option with several 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. If opening doors solves a spillage test, consider door undercuts, transfer grilles, jumper ducts or in-door transfer grilles (Figure 312-4-3).

Figure 312-4-2: Combustion air intake

Figure 312-4-3: Transfer grille

313 Steady State Efficiency Testing

Combustion analyzer used for testing must be within the manufacturer's calibration period and have a calibration sticker with the calibration date affixed to it. The analyzer should be started-up (calibrated) in a source of known fresh air during the calibration period – usually outside the home.

313-1 Category I Appliances

The following inspection procedures and maintenance practices are required for all Category I appliances in addition to items 1 through 11 as noted in section 31111, "Gas Burner Inspection, Testing and Correction".

- Test holes
  - Single wall pipe is preferred location for test holes, but double wall B vent can be drilled if necessary. If B vent is drilled, seal inner pipe with high temperature RTV caulk

(or equivalent) and metal tape over the outer pipe. Caulk must be red in color and rated to 600°F.
    - Single wall pipe is to be sealed with high temperature metal tape or metal plugs.
    - Butyl tape is not to be used.
- Determine steady-state efficiency (SSE) using flue gas analyzer measuring in undiluted flue gases below the draft diverter. Where the appliance has multiple burners and cells, each cell of the heat-exchanger must be tested separately.
- Measure O2 level and stack temperature in undiluted gases (before they enter the draft hood). O2 level should be between 4% and 9%. Net stack temperature should be between 300°F and 600°F.

313-2 Fan Induced Appliances

The following inspection procedures and maintenance practices are required for all fan induced appliances in addition to items 1 through 11 as noted in section 311-1-1, "Gas Burner Inspection, Testing and Correction".

- Test holes
    - Test hole should be located about 1 foot away from where the gases exit the appliance.
    - Test hole should be in a straight piece of vent pipe away from turns.
    - Single wall pipe is preferred location for test holes, but double wall B vent can be drilled if necessary. If B vent is drilled, seal inner pipe with high temperature RTV caulk (or equivalent) and high temperature metal tape or metal plugs over the outer pipe. Caulk must be red in color and rated to 600°F.
    - Single wall pipe is to be sealed with high temperature metal tape.
    - Butyl tape is not to be used.
- Determine steady-state efficiency (SSE) using flue gas analyzer.

- Measure O2 level and stack temperature. O2 level should be between 4% and 9%. Net stack temperature should be between 300ºF and 480ºF.

313-3 Direct Vent Sealed Combustion Appliances (+ 90% condensing – Figure 313-3-1)

The following inspection procedures and maintenance practices are required for all direct vent sealed combustion appliances in addition to items 1 through 11 as noted in section 311-1-1, "Gas Burner Inspection, Testing and Correction".

- Inspect the secondary heat exchanger and clean as needed.
- Test holes
  - The recommended test point for condensing appliances is to sample the gasses at the outside of the house by inserting the test probe into the PVC vent pipe at least 6 inches.
  - If testing cannot be done on the exterior because the vent pipe is not accessible, testing can be done by drilling the PVC vent pipe near the furnace. Test hole must be drilled and tapped with threads for 1/8" pipe threads and then sealed with a plastic pipe plug and sealant. Proper technique and equipment must be used to seal this pipe as it is under positive pressure and improper sealing will allow vent gasses to enter the house.
  - Test holes can be drilled in vertical pipes or the top half of horizontal pipes.

Figure 313-3-1: Direct vent sealed combustion furnace

- Determine steady-state efficiency (SSE) using flue gas analyzer.
  - Measure O2 level and stack temperature. Adjust as necessary to meet Product Manufacturer's Instructions for net stack temperature and O2 (generally, O2 is between 4% and 9%).

314 Heating Appliance Venting

Inspect chimney, vents and vent connectors to ensure adequate draft, clearance, soundness and freedom from combustible deposits. Clean if necessary. Repair or replace sections of the venting system that are seriously corroded or rusted, contain cracks or holes, and/or are unsealed, loose, or disconnected.

If two appliances share a common vent following a wye connection, ensure that the common vent is properly sized for both appliances. See NFPA 54, Tables 3 and 4, for guidance.

Ensure all venting materials meet clearances from combustible materials in accordance with the applicable NFPA code. When called for, correct cases where vent clearance requirements are not met.

Ensure that vent/chimney connections are securely fastened. Horizontal runs in the vent connector should have a rise of at least ¼ inch per foot. When installing flue pipe terminations for 95% efficient furnaces/boilers/water heaters, use the goose neck application. Exhaust up and out with Intake pointed toward the ground. Maintain clearances per PMI (Figure 314-1).

Figure 314-1 Goose neck venting

314-1 Venting Devices, Materials and Sizing

The National Fire Protection Association (NFPA) is the authoritative source for information on material-choice and sizing for vent connectors and chimneys. The information in this venting section is based on the following NFPA documents. Consult these references for specific venting requirements and tables for vent and chimney sizing.

- NFPA 54: The National Fuel Gas Code
- NFPA 211: Standard for Chimneys, Fireplaces, Vents, and Solid-Fuel-Burning Appliances 2024 Edition

314-2 Vent Connectors

A vent connector connects the venting outlet of the appliance with the chimney. Approved vent connectors for gas-fired units are made from the following materials.

- Galvanized-steel pipe ($\geq$ 0.018 in. thick) 26 gauge,
- Type-B vent, consisting of a galvanized-steel outer pipe and aluminum inner pipe ($\geq$ 0.027 in. thick),
- Stainless-steel pipe ($\geq$ 0.012 in. thick),
- Type-L vent, like Type-B only with a stainless-steel inner pipe, or
- Various listed manufactured vent connectors.

A wye connector is the preferred connection when a common flue is used for more than one appliance. Vent connections are not to be located directly across from each other when an induced appliance is used.

314-3 Masonry-Chimney Liners

Masonry chimneys and clay tiled chimneys should have a liner if they are not properly sized. If an 80% furnace or boiler has been installed, the masonry chimney will need a liner as it is probably oversized. The liner should have a small air space between itself and the masonry structure of the chimney to insulate the liner from rapid heat loss. A liner used to vent solid fuel may not also be used to vent liquid or gaseous fuel.

Unlined masonry chimneys should be lined with galvanized-steel vent pipe, Type-B vent, or a flexible liner.

Unlined chimneys or chimneys with deteriorated liners should be relined. For interior chimneys, flexible metal liners may be used. For external chimneys, galvanized-steel vent pipe, Type-B vent or

a flexible metal liner, insulated with vermiculite or equivalent, may be used.

314-4 Sizing Vent Connectors and Chimneys
Sizing tables and procedures for chimneys and vent connectors are found in NFPA documents numbered 54, 31 and 211 as described earlier. NFPA 54, the National Fuel Gas Code, Part 11 provides tables for sizing various types of chimneys and vent connectors.

315 Forced Air System Standards

The overall system efficiency of an oil or gas forced air heating system is affected by blower operation, duct leakage, balance between supply and return air and duct insulation levels.

315-1 Furnace Repair[10]
When possible, furnaces should be repaired to a safe and efficient operating condition. Cracked heat exchangers should be replaced per manufacturer's instructions (Figure 3151-1).

Figure 315-1-1: Furnace heat exchanger

315-2 Furnace Operation Standards and Improvements
Apply the following furnace-operation standards to maximize the heating system's seasonal efficiency and safety. Refer to Table 300-4 for furnace operating guidelines.

- Check temperature rise between the supply air plenum and return air plenum after 10 minutes of operation. Measure supply air temperature at three different points and use the average. Refer to manufacturer's nameplate for acceptable heat rise (supply temperature minus return temperature). The heat rise should be between 40°F and 70°F with the lower end of this scale being preferable for maximum efficiency.

[10] SWS 5.0109.2, "Forced Air – Clean & Tune"

- Measure total external static pressure (TESP). TESP should be ≤ 175 Pa (≤ 0.70 in w.g.). See section 3191, “Total External Static Pressure”, for additional information.
- The fan-off temperature should be between 90°F and 100°F, with the lower end of the scale being preferable for maximum efficiency.
- The fan-on temperature should be 115°F if possible.
- The high-limit controller should shut the burner off before the furnace temperature reaches 200°F. Operate unit with blower disconnected to check high limit control and repair as necessary.
- If needed, seal (with compatible sealing materials) unsealed blower compartment openings and blower compartment door.

If the heating system does not conform to these standards, consider the following improvements.

- Reduce heat rise by cleaning or changing dirty filters, cleaning the blower, increasing fan speed and improving ducted air circulation.
- Adjust fan control to conform to the above standards or replace the fan control if adjustment fails.
- Adjust the high-limit control to conform to the above standards or replace the high-limit control.

In all cases, the following furnace measures will be done:

- Furnace filters shall be cleaned or replaced. Two extra filters of proper size and type shall be left with the client. If client has 4" or 5" filter present, leave 1 extra plus install the new 1 in their furnace. A total of 2 filters. Also, educate the client about filter maintenance. Filter changing procedure shall be explained to client.

- Pull the blower fan and clean. Vacuum the compartment (Figure 315-2-1).
- Inspect the blower assembly's electrical wiring system for bad insulation and loose connections and repair as necessary.
- Inspect the blower and squirrel cage for excessive free play and correct as necessary.
- The blower motor shall be lubricated if appropriate.
- The thermostat shall be checked, cleaned and leveled.

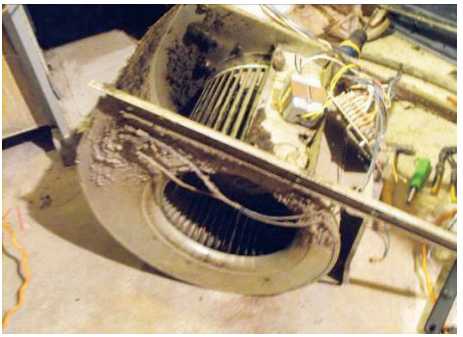


Figure 315-2-1: Pull blower fan and clean

Furnace Operating Temperatures

Table 300-4

Inadequate heat rise, Condensation and corrosion possible.		Heat rise good for both efficiency and avoidance of condensation.		Heat rise excessive. Check fan, heat exchanger, ducts and fan speed.	
20°	40°	40°	70°	70°	95°
Heat rise = Supply temperature – Return temperature					

Excellent fan-off temperature if comfort is acceptable.		Borderline acceptable. Consider replacing fan control.		Unacceptable range. Savings possible by replacing fan control.	
90°	100°	100°	115°	115°	130°
Fan-off Temperature					

Excellent. No action needed.		Fair. Consider fan control replacement only if fan-off is unacceptable.		Poor. Consider fan control replacement.	
100°	115°	115°	130°	130°	150°
Fan-on Temperature					

315-3 Ducts

315-3-1 Duct Leakage Sites

The following joints should be inspected and sealed (Figure 315-3-1-1). Ducts located outside the thermal boundary should be sealed.

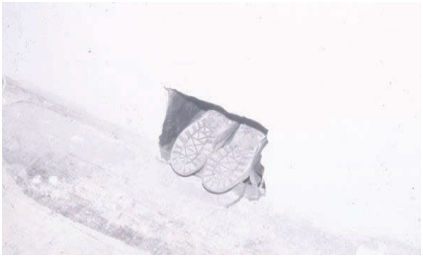


Figure 315-3-1-1: Inspect the ducts!

- Seal holes in the air handler and joints between the air handler and the supply and return ducts[11].
- Filter slot must have cover that will seal the opening but is easy for the occupant to open and close (Figure 315-3-1-2)[12].
- Seal leaky joints between main supply and return ducts and their branches (Figure 315-3-1-3).
- Seal leaky joints between building materials composing cavity return ducts, like panned floor cavities and furnace return platforms. Cavity return ducts may be replaced with new metal return ducts.
- Seal leaky joints between supply and return registers in the floor, wall and ceiling to which they are attached.

Figure 315-3-1-2: Metal filter

Figure 315-3-1-3: Seal leaks and connections in supply and return

- Secure metal duct joints with screws, seal them with mastic, and support joints with duct hangers.

[11] SWS 5.0106.1j, “Air Handler Jacket”
[12] SWS 5.0106.1k, “Filter Slot”

- Flex duct runs should be mechanically attached to the plenum/trunk/boot with clamps or cable ties and sealed. Flex duct should be run as straight as possible with a minimum of long radius turns and should be supported with appropriate hangers to prevent sagging.
- Permanently seal open supply and return registers in unconditioned areas (Figure 315-3-1-4).
- Patch or replace metal ducts that have rusted through and ducts with holes cut in them (Figure 315-3-1-5).
- Seal penetrations made by wires or pipes traveling through ducts. Pipes and wires may be moved and the holes patched.
- Seal return air grilles in basement (Figure 315-3-1-6). Re-check temperature rise and total external static pressure (see section 319-1, "Total External Static Pressure) to assure that it is within the operating limits of the furnace.

Figure 315-3-1-4: Permanently seal registers in unconditioned

Figure 315-3-1-5: Seal holes in ducts

Figure 315-3-1-6: Return air grilles should be sealed

315-3-2 Duct Sealing Materials[13]
Duct mastic is the required duct sealing material because of its

[13] SWS 5.0106.1, "Duct Sealing"

superior durability and adhesion. Tapes cannot be used for duct sealing in the Illinois Weatherization Program (Figure 315-3-2-1 and Figure 315-3-2-2)**.**

Seal leaks less than 1/4" using fiberglass mesh and mastic. Mastic alone is acceptable for holes less than 1/8" in size that are more than 10' from air handler if total external static pressure is less than 1" of water column (250 Pa)[14].

Seal leaks between 1/4" and 3/4" using a two stage process. Install temporary tape as a backing material. Seal with fiberglass mesh and mastic that extends at least 1" past the temporary tape on all sides.[15]

Repair leaks larger than 3/4" using a sheet metal patch. Mechanically fasten patch before applying mastic. Install fiberglass mesh and mastic over the seam, overlapping repair joint by at least 1" on all sides.[16]

Tape by itself is not to be used as it cannot be expected to

Figure 315-3-2-1: Tape is not to be used for sealing ducts in the Illinois WX Program

Figure 315-3-2-2: Duct mastic used to seal duct joints

Figure 315-3-2-3: Tape is not expected to hold a joint together

[14] SWS 5.0106.1f, “Seal Leaks Less than ¼”
[15] SWS 5.0106.1g, “Seal Leaks Between ¼” and ¾”
[16] SWS 5.0106.1h, “Seal Leaks Greater than ¾”

hold a joint together nor expected to resist the force of compacted insulation or joint movement (Figure 315-3-2-3). Joints should rely on mechanical fasteners to prevent joint movement or separation and mastic for sealing.

315-3-3 Duct Insulation[17]

Insulate supply and return ducts that run through unconditioned areas outside the thermal boundary such as vented crawl spaces and attics. Use minimum R8 insulation on supply ducts.

- Always perform necessary duct sealing before insulating ducts.
- Use fiberglass insulation 3 to 6 inches thick (minimum R8) with foil-scrim-kraft facing or vinyl facing. Vapor barrier must be placed to the outside with no exposed insulation.
- Insulation should cover all exposed ducts, especially in air conditioned homes. Use an approved UL 181 tape so no gaps exist in the vapor barrier.[18]
- Insulation should be fastened by mechanical means such as stuck-ups, twine, or plastic straps. Ensure insulation is in full contact with the ducts.
- If spray polyurethane foam is used, apply foam to the prescribed R-value in a continuous layer over entire exterior duct surface using a pass thickness maximum in accordance with manufacturer specifications. No spray foam may be installed on ducts inside the thermal boundary.[19]

315-3-4 Duct System Airflow

The airflow capacity of the air handler may be checked in relationship to the size of the furnace or air conditioner. For combustion furnaces there should be 110 to 150 cfm of airflow for each 10,000 Btuh of output. Central air conditioners should deliver 400 cfm of airflow per ton of cooling capacity. Heat pumps should deliver 450 cfm of airflow per ton of heating capacity.

[17] SWS 5.0107.1, “General Duct Insulation”
[18] SWS 5.0107.1e, “Sealing”.
[19] SWS 5.0107.2c, “Installation”

315-4 Central Air Conditioners (Figure 315-4-1)

315-4-1 Cooling Clean & Tune[20]

- Measure air flow across the evaporator coil. Airflow across the indoor coil should be 400 CFM per ton for a wet coil (condensation on coil) and 425 CFM per ton for a dry coil (no condensation on coil), plus or minus 50 CFM. Pressure drop across cooling coils will be in accordance with manufacturer specifications.
- Check for correct amount of refrigerant. Follow the manufacturer's specification for refrigerant charge. The airflow across the indoor coil should be adjusted and verified before the refrigerant charge is checked. Any refrigerant that must be evacuated must be captured rather than illegally releasing it to the atmosphere.
- Test for refrigerant leaks using a leak detector.
- Clean the outdoor condenser coil and straighten bent fins. Remove debris from inside unit. Clear debris, foliage, grass, etc. from within 3 feet of the unit.
- Ensure that suction line is insulated between indoor and outdoor coils; replace missing and defective insulation.
- Check for and seal duct leakage in central systems. Duct sealing and insulation is especially important for ductwork running through unconditioned spaces. This work should have been completed by the weatherization workers.
- Verify the correct electric control sequence and make sure that the heating system and cooling system cannot operate simultaneously.
- Inspect electric terminals, clean and tighten connections and apply a non-conductive coating if necessary.

Figure 3154-1: Central AC

[20] SWS 5.0109.1, "Condensers"

- Oil motors and check belts for tightness and wear.
- Check the accuracy of the thermostat.

Dirty air conditioning coils located in main ducts or air handlers are a common cause of low airflow and resultant low heating and cooling efficiency.

- Identify the coil location and the coil surface where the air enters - most of the dirt will be attached to this surface.
- Remove access panel in air handler or duct; or cut access panel in duct; or disassemble duct to gain access to air-conditioning coil.
- Using a soft brush and vacuum, remove surface dust, dirt and lint.
- Spray the coil with cleanser and after a while spray water to rinse out the cleanser and dirt. Repeat the spraying if necessary.
- Observe whether the pan and drain hose are doing their job. Water and cleanser should be flowing out the end of the hose, not overflowing into the duct. Clean the pan and unplug the hose if necessary.

315-4-2 Central Air Conditioner Replacement

Central air conditioners can be upgraded to more efficient models. Replacement central air conditioners must be ENERGY STAR rated with a minimal SEER2 of 14.3 or the current ENERGY STAR minimum SEER2 requirement. Mobile home air conditioners shall also meet the current ENERGY STAR SEER2 requirements when both the furnace and central air conditioner are being replaced. When only the central air conditioner is being replaced, a maximum SEER shall be achieved accounting for the evaporator coil and furnace blower configuration. The SEER rating of the unit must be submitted to OCA for approval.

Air conditioners shall be selected to have a rated sensible heat ratio (SHR) of 0.75 or less. Indoor coils and line sets shall also be cleaned or changed if a different refrigerant type will be used in the system. All new air conditioners shall carry a minimum one-year

warranty on parts and labor and a five-year warranty on the compressor.

Each client shall receive all manufacturer's product warranty information, clear maintenance instructions, educational information and a local telephone number for warranty problems.

Contractor shall size the system properly utilizing the *Residential Load Calculation, Manual J* by the Air Conditioning Contractors of America or other approved method. Sizing calculations must be provided to the Weatherization Agency for inclusion as a permanent part of the client file. The following characteristics of the house and occupants shall be considered:

- The size and volume of the home and the number and orientation of the windows.
- The amount of existing insulation and insulation to be added as part of weatherization.
- The tightness of the home. It is important to remember that the ACH[21] value used in most weatherization work in the midwest is a winter calculation. The ACH during the cooling season – that which is used in cooling load calculations – is usually significantly less.
- The amount of shading on windows, walls and roof.
- The number of occupants and the degree of internal heat gain they generate.
- Ensure that unit can move adequate air corresponding to the size of the unit.

Following installation of new air conditioning system, contractor shall check, test and meet the requirements of section 315-4-1, "Cooling Clean and Tune".

[21] Air Changes per Hour

315-5 Heat Pumps

All heat pump systems and mini-splits should be sized using an approved Manual J load calculation provided by the contractor, with post-retrofit dwelling characteristics factored into the calculation.[22] The heat pump should be sized with adequate auxiliary heat to supply the structure with adequate heat in case of heat pump failure, during defrost modes and as auxiliary heat during low outdoor temperatures. Most properly sized air source heat pumps and mini-splits in Illinois will not be able to maintain indoor design temperatures when outdoor temperatures reach typical outdoor design temps without auxiliary heat. When installing all heat pumps, the outdoor unit must be installed off the ground using a wall mount bracket, riser pad, or 5-star pad. (Figure 315-5-1).

Figure 315-5-1: Examples of heat pumps on a wall mounted bracket, a riser pad, and a 5-star Pad

Auxiliary heat can be a separate heating source such as electric resistance baseboard heat when installing mini-splits, or resistance heat strips can be added to the air handler in cases where an air source heat pump central system is being installed. Cost of including these heat sources should be included with the heat pump installation cost. Other auxiliary heat sources should be reviewed with your Weatherization Specialist. Client education is required when using auxiliary heat.

[22] SWS 5.0108.1a, “Load Calculation”

Existing central heating appliances cannot be used as auxiliary heat sources unless a common thermostat can automatically operate the appliance when auxiliary heat is required.

- Heat pumps shall be ENERGY STAR rated. For split systems, minimum HSPF2 shall be 7.2 with a minimum SEER2 of 14.3 (EER2 12 or greater) or the current ENERGY STAR minimum SEER2 requirement.
- Measure air flow across the indoor coil in heating mode. Airflow across this coil should be 450 CFM per ton plus or minus 50 CFM.
- Check for correct amount of refrigerant. Follow the manufacturer's specification for refrigerant charge. The airflow across the indoor coil should be adjusted and verified before the refrigerant charge is checked. Any refrigerant that must be evacuated must be captured rather than illegally releasing it to the atmosphere. For systems with fixed metering devices (capillary tube or fixed orifice), the evaporator superheat method should be used along with the manufacturer's recommendations. For systems with thermostatic expansion valves (TXV), the subcooling method should be used along with the manufacturer's recommendations.
- Test for refrigerant leaks using a leak detector.
- Check for and seal duct leakage in central systems. Duct sealing and insulation is especially important for ductwork running through unconditioned spaces (see section 315-3, "Ducts").
- Inspect electric terminals, clean and tighten connections and apply a non-conductive coating if necessary.
- Oil motors and check belts for tightness and wear.
- Check the accuracy of the thermostat.
- Test for proper operation of the heat pump defrost control. This control for the outdoor coil must be adjusted to optimize heating efficiency.

315-6 Room Air Conditioner Replacement

Room air conditioners (Figure 315-6-1) must be ENERGY STAR rated (ENERGY STAR ratings are based on unit size). All new air conditioners shall carry a minimum one-year warranty on parts and labor.

Figure 315-6-1: Room air conditioner

Window units shall be sized appropriately. The guide[23] shown as Table 300-5 may be used to size window units.

Window Air Conditioning Unit Sizing Chart

Table 300-5

Area To Be Cooled (square feet)	Capacity Needed (BTUs per hour)
100 to 150	5,000
150 to 250	6,000
250 to 300	7,000
300 to 350	8,000
350 to 400	9,000
400 to 450	10,000
450 to 550	12,000
550 to 700	14,000
700 to 1,000	18,000
1,000 to 1,200	21,000
1,200 to 1,400	23,000
1,400 to 1,500	24,000
1,500 to 2,000	30,000
2,000 to 2,500	34,000

[23] From energystar.gov

The following adjustments may be made[24].

- Reduce capacity by 10% if room is heavily shaded.
- Increase capacity by 10% if room is very sunny.
- If more than two people regularly occupy room, add 600 Btus for each additional person.
- Add 4,000 Btu if unit is used in kitchen.

315-7 Condensate Removal[25]

Convey all condensate from all cooling coils, condensing furnaces, etc. to the exterior of the building. Condensate from condensing furnaces must first pass through a neutralizer if using waste lines for disposal.

Install condensate piping with not less than 1/8" per foot (1% slope) towards the termination point.

Install vents and traps on condensate drain lines in accordance with manufacturer specifications and applicable building code and in a manner that allows for cleaning of condensate lines without cutting the existing pipe.

Install a secondary drain pan under all condensing appliances installed in or above conditioned space and where water damage may occur to the structure. Install an independent condensate drain for the secondary drain pan that drains to a visible termination location. Slope drain pan towards the condensate drain.

When there is potential for condensation or freezing of the drain line, insulate condensate drain lines to a minimum of R-4 with insulation that contains a Class II or greater vapor retarder.

Install condensate drain pumps when condensate cannot be drained by gravity.

[24] From energystar.gov
[25] SWS 5.0102.1, "Condensate Removal"

If termination of condensate drain is to the outdoors, direct it downwards with an elbow fitting at the end of the exterior termination.

316 Hydronic Standards

The following standards refer to hydronic systems commonly found in single family homes.
Observe the following standards for servicing hydronic heating systems in single family structures.

Figure 316-1-1: Warm water boiler

316-1 Hot Water Systems (Figure 316-1-1)

- Repair water leaks in the system.
- Clean fire side of heat exchanger of noticeable dirt.
- Lubricate circulator pump if necessary.
- Boiler should not have low-limit control for maintaining a minimum boiler-water temperature unless the boiler is heating domestic water in addition to space heating.
- Test pressure tank for its rated air pressure.
- High-limit control should deactivate boiler at 200° F or less.
- Test pressure relief valve and replace or install new valve if necessary.
- Bleed air from radiators and piping through air vents in elbows or radiators. Most systems have an automatic fill valve.
- Verify that water pump, low water cutoff, automatic feed control and high pressure controls are in operating condition and repair as necessary.
- Insulate hot water supply lines passing through unconditioned areas.
- Check, clean and level thermostat.
- Vacuum and clean baseboard unit fins if appropriate.

- Post on equipment, or in a conspicuous location, a list of all systems and components inspected, results, and services performed that includes legible service personnel name, contact information, and date of service.[26]

316-2 Steam Systems

For steam systems, observe the following.

- Check or replace steam vents and steam traps.
- Verify that water pump, low water cutoff, automatic feed control and high-pressure controls are in operating condition and repair as necessary.
- Replace/clean sight glass if water level cannot be seen due to dirt build-up on glass.
- Post on equipment, or in a conspicuous location, a list of all systems and components inspected, results, and services performed that includes legible service personnel name, contact information, and date of service.[26]

317 Unvented Space Heaters

Removal of unvented space heaters is required by the contractor, even if used as a secondary heat source and the unit conforms to ANSIZ21.11.2. Unvented space heaters must be removed from the site by the contractor prior to weatherization but may remain until a replacement heating system is in place.

Figure 318-1: Advanced thermostat

318 Advanced and Automatic Setback Thermostats[27]

Both Advanced (or "Smart", Figure 318-1) and automatic setback thermostats (Figure 318-2) may be

Figure 318-2: Automatic setback thermostat

[26] SWS 5.0204.1, "Documentation"
[27] SWS 5.0101, "Thermostat Replacement"

installed in the Weatherization Program. Selection of the thermostat type should be based on willingness and ability of client to use the selected thermostat. Advanced thermostats must be ENERGY STAR certified.

- Select a double-setback programmable thermostat that allows for full functionality of the installed system (supplementary heat, emergency heat, fan only, ventilation control, etc.).
- When replacing existing thermostats, identify and dispose of any mercury containing thermostats in accordance with Environmental Protection Agency (EPA) guidance.
- All thermostats must be installed according to manufacturers' instructions.
- Thermostats are to be level. Installation shall include an appropriate wall plate.
- New setback thermostats should generally be installed in the same location as the old thermostats. In cases where the old thermostat is in the kitchen, in direct sunlight, over a heat register or radiator, or other location which would impede performance, the new setback thermostat should be relocated.
- Seal penetrations for control wiring with a durable sealant (e.g., caulk, silicone) that complies with applicable fire safety code.
- A heating/cooling thermostat must be used if the home is centrally air conditioned.
- Setback thermostats should have a minimum of two setback periods, allowing residents to set temperature back (or up for air conditioning) twice a day—once for sleep and once for vacancy, such as work and school.
- Manual setback or large-lettered thermostats should be installed for seniors or people with visual impairments as appropriate.
- Occupants should be instructed on the setting and operation of new setback thermostats and the replacement of batteries for thermostats utilizing batteries.

319 Heating System Replacement Standards

All new heating appliances shall carry a minimum one-year warranty on workmanship. New condensing units must have a lifetime manufacturer warranty on the primary heat exchanger and a minimum 10-year warranty on the secondary heat exchanger.

Each client shall receive all manufacturer's product warranty information, PMI manual, clear maintenance instructions, educational information and a local telephone number for warranty problems.

New heating appliances that are to be installed on a concrete, dirt, or damp floor, should be raised a minimum of 1 inch above the floor surface, or per local code. Safely remove and dispose of existing unit. Seal openings in chimneys where atmospheric vented appliances are eliminated.

Following completion of furnace replacement, contractor shall conduct a combustion safety test (see section 312, "Combustion Safety Testing").

Sizing calculations must meet accepted standards such as Manual "J". Sizing should account for lower heating loads resulting from insulation and air sealing work. Sizing calculations must be provided to the Weatherization Agency by the weatherization contractor for inclusion as a permanent part of the client file.

If a home has central air conditioning and furnace is replaced, the cost for the furnace replacement work must include reinstallation of the existing central air conditioning unit.

Replacement heating appliances should meet the guidelines and minimum efficiency ratings as shown in Table 300-6.

See section 411, "Mobile Home Furnaces", for additional information regarding mobile homes.

Replacement System Minimum Efficiencies

Table 300-6

Natural Gas/LP Furnaces	95%, Direct vent sealed combustion
Oil Furnaces	85%
Warm Water Gas Boilers	95%
Steam Boilers	80%
Oil Boilers	80%
Central Air Conditioners	Current ENERGY STAR minimum[28]
Air Source Heat Pumps & Mini-Split Systems	Current ENERGY STAR minimum[29]

Note that unvented space heaters must be removed from the site by the contractor but may remain in place until a replacement heating system is in place. See section 317, "Unvented Space Heaters", for additional information.

319-1 Total External Static Pressure (TESP)

Total external static pressure (TESP) shall be measured to determine appropriate fan motor type for furnace replacement or if high static pressure in the system must be addressed.

- If the TESP ≤ 175 Pa (≤ 0.70 in. w.g.), a variable speed fan motor may be used.
- If the TESP is between 175 Pa (0.70 in. w.g.) and 250 Pa (1.0 in. w.g.),
  - An X13 fan motor must be used, or
  - The static pressure in the duct system may be addressed. If the TESP can be reduced to under 175 Pa, a variable speed fan motor may be used.

[28] As of January 2025, minimum SEER2 is 14.3

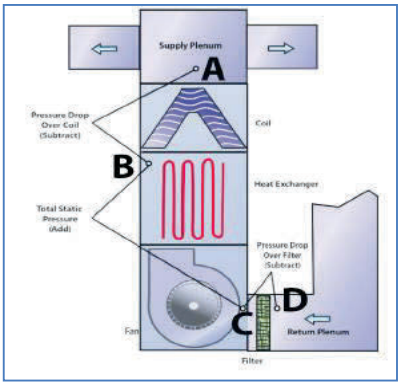
[29] As of January 2025, minimum HSPF2 of 7.2, minimum SEER2 of 14.3 (or EER2 of 12 or greater)

- If the TESP > 250 Pa (1.0 in. w.g.), the static pressure in the duct system must be addressed as part of furnace replacement.

TESP is to be measured as shown in Figure 319-1. Measure pressure at B and C. Add the absolute value of the two pressure readings.

If the TESP is between 175 Pa and 250, additional readings may be taken at points A and D to help resolve the cause of the high TESP reading or a furnace with an X13 fan motor must be installed.

If the TESP exceeds 250 Pa, additional readings must be taken at



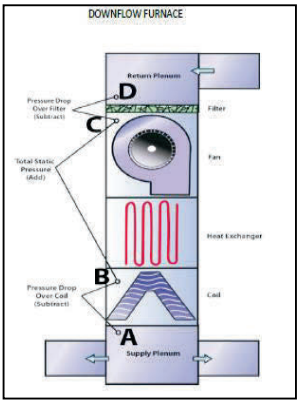


Figure 319-1-1: Static pressure reading locations for upflow and downflow furna

points A and D to help determine the cause of the high TESP reading. TESP must be brought under 250 as part of the furnace replacement measure or the furnace cannot be replaced. If the TESP can be brought under 175 Pa, a furnace with a variable speed fan motor may be used. Otherwise, a furnace with an X13 fan motor must be installed. See TESP reference document for guidance on lowering TESP.

319-2 Natural Gas and Propane Fired Heating Systems

New heating appliances must be installed to manufacturer's specifications, following all applicable building and fire codes.

- Replacement gas furnaces shall have a minimum Annual Fuel Utilization Efficiency (AFUE) of 95% and must be direct vent, sealed combustion (2-pipe) units.
- If a 95% unit cannot be installed for whatever reason, a state approved Replacement Waiver must first be obtained.
- Warm water gas boilers must have a minimum AFUE of 90%.
- Clearances of heating unit and its vent connector to nearby combustibles shall be according to NFPA 54, tables 6.2.3 (a) and 6.2.3 (b).
- All gas piping must be installed according to the American Gas Association (AGA) National Fuel Gas Code specifications and any other appropriate codes.
- All gas appliances must have a sediment trap that is serviceable. The sediment trap needs to include at least a 3" nipple and cap in the correct position for gas flow. (Figure 319-2-1).

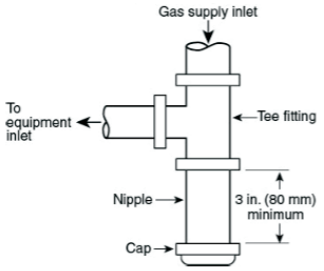


Figure 319-2-1: Sediment trap

- Sediment traps that are incorrectly installed with the gas supply flowing across the trap rather than towards it are not permissible (Figure 319-2-2).

Figure 319-2-2: Incorrectly installed sediment trap

- Gas unions are not allowed to be installed inside the furnace/boiler cabinet (Figure 319-2-3).
- All gas lines must be solid pipe inside the furnace/boiler cabinet. Yellow UL listed stainless steel flexible connectors are allowed to be used outside of the furnace/boiler/water heater cabinet.

- When installing gas pipe on Mobile Home appliances, refer to Mobile Home sections 411 and 412.
- Test water heater to ensure that it vents properly after installation of direct vent sealed combustion furnace after setting-up house for worst case depressurization (see section 312-1, “Worst Case Depressurization”).

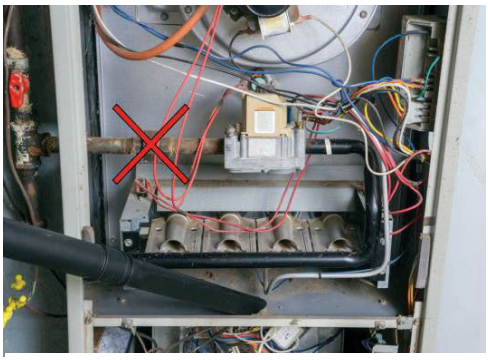


Figure 319-2-3: Gas unions are not allowed

- Ensure proper sediment trap on gas line.
- Measure gas pressure to ensure that it is within manufacturer’s specifications. Adjust gas pressure if necessary to obtain proper gas input. Verify Btu input by clocking gas meter (see Table 300-2).
- Set thermostat’s heat anticipator to the amperage measured in the control circuit.
- Repair or replace sections of the venting system that are corroded, rusted, clogged or blocked, contain cracks or holes or are unsealed, loose or disconnected.
- Follow manufacturer’s venting instructions and NFPA 54 Chapters 7 and 10 to establish a proper venting system.
- When installing flue pipe terminations for 95% efficient furnaces, boilers, and water heaters use the goose neck application. Exhaust, up and out with Intake

Figure 319-2-2 Goose neck venting

pointed toward the ground. Maintain clearances per PMI (Figure 319-2-2).

- Properly sized and installed flexible gas appliance connectors are permitted on furnace, boiler, and water heater installations. Yellow UL listed stainless steel flexible connectors are allowed to be used outside of the furnace/boiler/water heater cabinet.
- Repair or replace unsafe power supply to appliance.

Install a properly sized and dedicated circuit to the heating appliance if one is necessary. All electrical penetrations of the furnace/boiler cabinets must include an appropriate connector for the type of wire being used. For example, using a romex or conduit connector for penetrations through the cabinet of the appliance. (Figure 319-2-3).

Figure 319-2-3: UL listed approved yellow flex line

319-3 Furnace Installation[30]

Observe the following standards in furnace installation.

- All furnace work must be in compliance with:
  - The Uniform Mechanical Code
  - National Fire Prevention Association (NFPA)
  - Local Codes (where existing)
  - Furnace Manufacturer's Specifications
- Furnace shall be sized to the home's approximate heating load, using post-weatherization R-values and infiltration assumptions. Furnace sizing must be compared to the contractor's Manual J document provided to the agency.
- If funds are available, return ducts and/or supply ducts must be included with furnace replacement to improve air distribution

[30] SWS 5.0108.4, "Furnace Replacement"

and to establish acceptable values for static pressure and heat rise.

- Supply and return plenums must be mechanically fastened with screws and sealed to air handler to form an essentially airtight connection.
- Heat rise (supply temperature minus return temperature) must be within manufacturer's specifications.
- High limit must stop fuel flow at less than 200°F. Furnace must not cycle on high limit.
- Fan control should be set to activate fan at 115°F and deactivate it at 90°F if possible. Slightly higher settings are acceptable if these recommended settings cause a comfort complaint.
- Static pressure, measured in both supply and return plenums, must be within manufacturer's specifications. Static pressure outside of manufacturer's specifications cannot be corrected with the installation of a grille on the return air plenum.
- Install equipment connections (e.g., electrical service, condensate drains, ductwork, fuel, venting, refrigerant lines) to allow for necessary service and repair access to all portions of the equipment.[31]
- Blower must not be set to operate continuously.
- Holes in the air handler must be sealed by installer with mastic.
- New central forced air furnaces and new duct systems will have minimum MERV 6 filtration with no air bypass around the filters. Filters must be held firmly in place and provide complete coverage of blower intake or return register. Filters must be easy to replace.
- Existing air conditioning coils must be re-installed with an airtight, removable panel, providing convenient access for cleaning.
- Furnaces which do not have a readily accessible filter access/location should have a filter rack with a cover, installed in the return air plenum, in an accessible location.

[31] SWS 5.0108.4j, "Connections"

- External filter racks must have a cover that seals the filter opening.
- Install a condensate pump where needed to reach an appropriate drain, if necessary.
- No used furnaces may be installed.
- Contractors must remove and dispose of equipment being replaced unless otherwise directed by the agency.

319-4 Boiler Installation[32]

- Warm water boilers shall have a minimum seasonal efficiency of 95%. **A properly configured outdoor reset control is required with new warm water boiler installations.**
- Steam boilers shall have a minimum seasonal efficiency of 80%.
- All boiler work must follow:
  - The Uniform Mechanical Code
  - National Fire Prevention Association (NFPA)
  - Local Codes (where existing)
  - Boiler Manufacturer's Specifications
- Boiler shall be sized to the home's heating load, accounting for weatherization heat loss reductions.
- Install equipment connections (e.g., electrical service, drains, fuel, venting) to allow for necessary service and repair access to all portions of the equipment.[33]
- Boilers must have an IID and vent damper or be power vented.
- Maintaining a low-limit boiler temperature is not permitted unless the boiler is used for domestic water heating.
- An effective air-excluding device or devices must be part of the new hydronic system.
- The pressure tank must be replaced or tested for correct pressure during boiler installation.

[32] SWS 5.0203.1, "Boilers"
[33] SWS 5.0203.1g, "Connections"

- A pressure relief valve must be installed with the new boiler and discharge pipe installed to within 6 inches of the floor, with no cap or threads.
- Extend new piping and radiators to conditioned areas like additions and finished basements, currently heated by space heaters.

319-5 Space Heater Installation

Replace combustion space heaters with sealed combustion, direct vent space heaters. If conditions in the house do not permit the installation of a sealed combustion direct vent space heater, an atmospherically vented space heater may be installed. The space in which the space heater is installed shall be treated as a combustion appliance zone (CAZ). A combustion safety test (section 312, "Combustion Safety Testing") shall be conducted.

Install space heater exactly as specified by manufacturer. Installation of ventless space heaters is not permitted under the Illinois Home Weatherization Assistance Program.

319-6 Wood Heating Installation

- All installations must meet manufacturer's specifications.
- All wood heating units must be certified to meet the EPA phase II emission standards or local standards, whichever are most strict.
- Installed units must be certified and labeled by:
    a. National Fire Protection Association under 211; or
    b. International Conference of Building Officials; or
    c. Other equivalent listing organization.
- All clients receive in-home operation instructions to include proper wood-burning practices, safety information and proper maintenance, e.g., stack thermometers, the need for fire extinguishers, etc.

320 Water Heater Retrofits

320-1 Tank Insulation[34]

Do not insulate water heater if the unit has a manufacturer's warning against adding additional insulation. If label is not visible, assume that insulation cannot be added to the tank.

Water heater must be operating in a safe condition before adding insulation. Water heater must not be leaking.

Tank insulation must be a minimum R10.

Insulation must have a flame spread and smoke development index of 25/450 or less when tested in accordance with ASTM E84 or UL 723 and is clearly labeled with the R-value.

Insulation shall be secured to the water heater utilizing:

- A minimum of three vinyl straps or belts commercially available for water heater jackets, or
- A minimum of three metal banding straps or wires, or
- A minimum of three strips of vinyl tape commercially available for water heater jackets. Each strip shall form two complete wraps around the water heater jacket.

Fasteners should not compress insulation more than 50 percent of its normal thickness.

Water heaters to receive tank insulation must have a temperature-and-pressure relief valve and a safety discharge pipe. If the existing relief valve is plugged or leaking, it must be replaced. Install a relief valve and discharge pipe if none exists. The pipe must terminate within 6 inches of the floor and be made of rigid metallic material. There shall be no threads or cap on the end of the discharge pipe.

[34] SWS 7.0301.2, "Tank Insulation"

Water heater insulation shall not obstruct pressure relief valves, thermostat, high-limit switch, plumbing pipes or access plates.

Insulation shall be cut and removed around all controls, service panels (including electrical access panels), air inlets, temperature/pressure relief valves, drain valves specifications and instruction panels.

No insulation shall be in contact with the floor.

Gas-fired water heater insulation

- Maintain a minimum clearance of 6", or the distance specified by the manufacturer,[35] between combustible tank insulation and water heater draft diverter and/or single wall metal vent materials. Maintain 1" clearance from B-vent or double wall flue pipe.
- Keep insulation at least 2 inches away from the access door to the burner.
- Do not insulate the tops of gas-fired water heaters.

Electric water heater insulation

- Insulation may cover the water heater's top if the insulation will not obstruct the pressure relief valve.
- Access holes must be left in the insulation for the heating-element thermostats.

320-2 Pipe Insulation[36]

- Insulate first 6 feet of both hot- and cold-water pipes minimum R3 insulation.
- Cover elbows, unions and other fittings to same thickness as pipe.

[35] SWS 7.0301.2d "Clearance"
[36] SWS 7.0301.1, "Pipe Insulation"

- Keep pipe insulation at least 6 inches away from single wall flue pipe and 1" away from double wall or b-vent flue pipe.
- Interior diameter of pipe sleeve must match exterior diameter of pipe.

320-3 Water Heater Replacement[37]

Water heaters may be replaced with DOE funds only if the SIR is 1.0 or greater, or if the local agency has obtained OCA approval for a Health and Safety related replacement.

Replacement water heaters must be installed by licensed plumbers.

All water heater work must comply with the International Residential Code (IRC), the National Fire Prevention Association (NFPA), local codes (where they exist) and the water heater manufacturer's specification. No used water heaters may be installed.

For electric water heaters, set both upper and lower thermostat to keep water at 115°F. All other water heaters should be set to medium.[38]

Note that water heaters installed in garages must be a minimum of 18 inches off the floor.

All replacement water heaters must have a pressure relief valve and a discharge pipe extending within 6 inches of the floor with no threads or cap.

Provide a level working space not less than 30" in length and 30" in width in front of the control side of the appliance. Install appliance and plumbing to allow for inspection, maintenance, and replacement of the appliance and its components, without

[37] SWS 7.0302.2, "Fuel-Fired Storage Tank Water Heater"
[38] Illinois Administrative Code Part 890: Illinois Plumbing Code, Section 890.690b "Water Temperature Safety"

disturbing other installed equipment, controls, piping, and components, other than what requires repair/replacement. Ensure that anode rod is accessible for replacement.
If appliance is installed in or above conditioned space or in a location where water damage could occur, install a drain pan according to the requirements of the International Residential Code (IRC). Drain pan to the exterior of the building.

Install a separate water cut-off valve for both the hot and cold water lines (some municipalities' code specifically prohibits a separate water cut-off for both; if so, please provide a copy of the municipal code to your local agency.

Install an expansion tank anytime a storage water heater is supplied with cold water that passes through a check valve, pressure reducing valve or backflow preventer. Connect the tank to the cold water supply line at a point that is downstream of all check valves, pressure reducing valves and backflow preventers. Size thermal expansion tanks in accordance with the tank manufacturer's instructions and applicable code.

Install dielectric unions when connecting copper to galvanized steel piping in accordance with the IRC and manufacturer specifications.

Permanently remove equipment from job site and recycle or dispose of removed equipment and refrigerant in accordance with local and federal law.

Provide occupants/owners with user's manual, warranty information, installation instructions, and installer contact information.

320-3-1 Electric Water Heaters[39].
Electric storage tank type water heaters must have a minimum Energy Factor (EF) of 0.93.

Install appliance where it is protected from freezing and accessible for service.

320-3-2 Heat Pump Water Heaters[40]
Electric heat pump water heaters must have a Uniform Energy factor (UEF) greater than or equal to 2.00 and must be ENERGY STAR rated.

Install appliance where it is in conditioned space and is accessible for service Must have sufficient volume of air, not less than 700 cubic feet, per manufacturer specifications. Install in location such that it will not affect indoor thermostat readings or blow directly on occupants or directly on adjacent surfaces (follow minimum distance requirements per PMI).

When adding a duct kit to a heat pump water heater to vent it outside, a kit specifically designed for the brand and model must be used to ensure a proper, efficient, and secure fit. If this duct goes through unconditioned space, the duct must be insulated to account for condensation issues that may otherwise occur.

320-3-3 Gas and Propane Water Heaters
Gas and propane storage tank type water heaters must have a minimum Uniform Energy Factor (UEF) of 0.64 and be ENERGY STAR rated with low NO_x burners.

[39] SWS 7.0302.1, "Electric Storage Tank Water Heater"
[40] SWS 7.0302.3, "Heat Pump Storage Tank Water Heater"

Properly sized and installed flexible gas appliance connectors are permitted on water heater installations. Yellow UL listed stainless steel flexible connectors are allowed to be used outside of the furnace/boiler/water heater cabinet.

Install appliance where it is protected from freezing and accessible for service.

In tight homes or homes where the mechanical room is located in living areas, replacement gas water heaters must be either power-draft or sealed-combustion. Sealed-combustion water heaters are preferred in tight homes where the water heater is in the living space.

320-3-4 Mobile Home Water Heaters
Mobile home water heaters may only be replaced with DOE funds if they have an SIR of 1.0 or greater, or if the local agency has obtained OCA approval for a Health and Safety related replacement. See section 412, "Mobile Home Water Heaters" for mobile home water heater replacement standards.

320-3-5 Tankless On-Demand Water Heaters[41]
Gas and propane tankless water heaters must have a minimum UEF of 0.87 and be ENERGY STAR rated.

Ensure water heater fits in the installation space with required clearances and will provide sufficient hot water for the occupants.

Ensure gas line to water heater is of properly sized for water heater burners. Note that some homes may not have the proper size gas line to the home or pressure to support the addition of a tankless water heater.

[41] SWS 7.0302.5, 'Tankless On-Demand"

321 Gas Ranges/Ovens/Cook Stoves

321-1 Inspection

- Inspect the oven/range/cook stove for gas leaks at the fittings using a gas leak detector.
- Gas burners shall be turned-on and visibly inspected. A *Potential Hazardous Condition* form shall be completed and given to the client if:
  - The flames have any discoloration, flame impingement or an irregular pattern, or
  - The burners are visibly dirty, corroded or bent.
- Inspect oven for stored materials and remove before testing.
- Turn on oven to bake temperature of 500^0F.
- Place test probe of CO analyzer on throat of oven exhaust.
- Test for CO after oven has reached steady-state (CO readings have steadied).
- CO shall not exceed 225 ppm as measured when measured in undiluted flue gases. If CO exceeds 225 ppm as measured, the following recommendations may be made:
  - Recommend cleaning to client if oven is excessively dirty and a *Potential Hazardous Condition* form shall be completed and given to the client.
  - The range may be replaced.

321-2 Replacement

Gas ranges/ovens may be replaced as a Health & Safety measure if high CO readings are found and/or the range/oven is non-repairable. DOE funds may not be used for gas range, oven, or cook stove replacement. **Non-operable ranges/ovens/stoves shall not be replaced.** State review and approval via a waiver is required for replacement and the new units must meet the following requirements.

- Units shall be free standing 30” range with a 4-burner cooktop, electronic ignition, oven window and interior light.
- Units shall be white or black – no special color orders.
- Installation shall include new flex-line and gas valve.
- Must be installed per manufacturer’s instructions.

- All packing materials from compartments shall be removed.
- Burners and oven shall be checked for proper operation.
- Instructions shall be left with client.
- Contractor shall remove old unit from home.
- Gas ranges may be replaced with electric ranges **IF** there is an existing electrical connection requiring no upgrade **AND** the client agrees to the switch.
- Oven shall be tested for CO per the above requirements. As measured CO shall be less than 225 ppm.

322 Contractor Checklist

- The HVAC Contractor Checklist is to be completed for each home where mechanical work is completed. This document is a fillable form located in the contractor portal in IWx and must be completed in full and checked off by the contractor who completes the work. All information requested on the contractor checklist for the heating system serviced must be provided.
- All readings are to be obtained directly from the heating system serviced and are not to be estimates derived from contractor service manuals.
- The Contractor Checklist must be completed for the Weatherization Agency for inclusion as a permanent part of the client file.
- Payment for services rendered by the HVAC contractor shall not be made until the Contractor Checklist is completed, signed and dated by the contractor who serviced the heating system.

400 – Mobile Home Standards

411 Mobile Home Furnaces

A great majority of mobile homes are equipped with downflow furnaces, designed specifically for mobile homes (Figure 411-1). A replacement furnace should never have a larger Btu rating than the mobile home manufacturer recommends, unless the home has been added onto. Mobile home furnaces are different from conventional furnaces in the following ways:

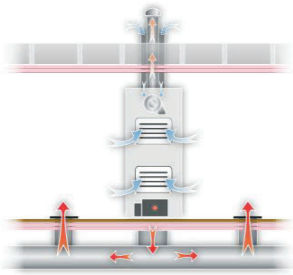


Figure 411-1: Typical mobile home downflow furnace

- Mobile home combustion furnaces are sealed-combustion units that use outdoor combustion air.
- Gas-fired furnaces contain kits to burn either propane or gas.
- Return air to the furnace usually passes through a large opening in the furnace rather than a ducted return. Supply air is returned to the furnace through the living space. The furnace closet door must have louvers or grilles that allow the air back to the furnace return air opening.

411-1 Furnace Replacement

Mobile home furnaces must be replaced by furnaces designed and listed for use in mobile homes. See section 319, “Heating System Replacement Standards”, for heating system replacement guidelines. A 95% replacement furnace should always be installed in a mobile home. If a 95% furnace can’t be installed, the local Weatherization Agency must request a waiver from the Office of Energy Assistance. If an 80% furnace is approved for installation, a new roof jack must also be included.

411-2 Furnace Maintenance

Mobile home furnaces should comply with the combustion safety and efficiency standards as discussed in sections 311-1 ("Natural Gas and Propane"), 311-2 (Electric Heating Systems), 311-3 (Wood Burning Safety) and 312 (Combustion Safety Testing).

411-3 Furnace Venting

Mobile home furnaces often use manufactured chimneys that include a concentric passageway for combustion air. When replacing a mobile home furnace, note any differences between the old and new furnace supply air paths. Follow manufacturer's instructions exactly.

Mobile home furnaces with concentric vents cannot be drilled and must be tested at the exhaust port which is often on the roof. If climbing on the roof to test the furnace is not safe (poor ladder footing, roof in poor condition), do not test the furnace.

Inspect the vent for signs of rust, cracks, holes or unsealed or disconnected sections. Repair or replace if necessary.

411-4 Ductwork

The following locations have been identified as the most serious duct problems in mobile homes:

- Floor and ceiling cavities used as return-air plenums. These return systems should be eliminated and replaced with central return-air[1] through the living space back to the furnace. – see section 411-4-1, "Converting Belly-Return Systems".
- Disconnected, damaged or poorly joined crossover duct – see section 411-4-2.
- The joint between the furnace and the main duct. The main duct may need to be cut open to access and seal these leaks.

[1] A central return is defined as a return air system with one return air grille. Return air may be ducted to the furnace or, as in the case of mobile homes, air returns to the furnace through louvered doors to the furnace closet.

- Joints between the main duct and its boots - the short duct sections joining the main duct to the floor register.
- Joints between duct boots and floor (Figure 411-4-1). Mechanically attach and seal with mastic. If gap is larger than ¾", first cover gap with fiberglass mesh tape and then seal with mastic[2].

Figure 411-4-1: Opening between duct boot and floor

- Pressure pan tests (see section 114, "Pressure-Pan Duct Test") should be conducted on the ducts following duct repair/sealing. Duct leakage test standards provided in section 411-4-4, "Duct Leakage Standards", shall be met.

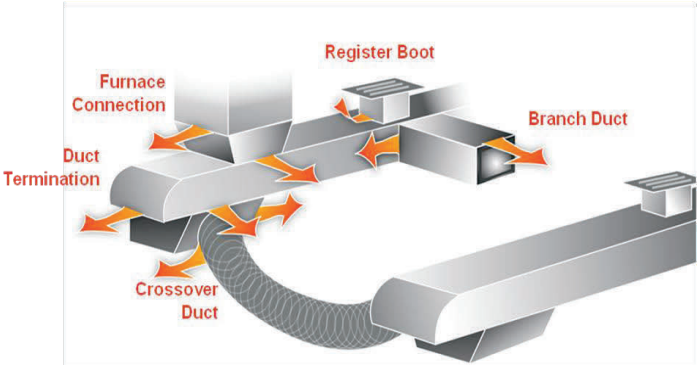


Figure 411-4-2: Potential mobile home duct leakage locations

- See Figure 411-4-2 for potential duct leakage locations.

Damaged duct work shall be replaced. New ducts shall be rigid metal made of minimum 26 gauge metal. Cut-out damaged sections. Insert and secure metal sleeve between remaining pieces of duct. Mechanically fasten at both inner and outer liner. Seal

[2] SWS 5.0105.5, "Replace MH Duct Boots"

joints with UL-listed sealant that is durable and structurally sound. Insulate metal sleeve to a minimum R8.

411-4-1 Converting Belly-Return Systems

The following standards shall be met when converting a belly-return system in a mobile home to a central return.

- A grill with at least 200 in^2 of net free area shall be added to the furnace closet door.
- All floor return registers shall be blocked with a durable material to keep floor insulation from being blown into the home.
- Completely block and seal all floor openings in the furnace closet using a fire retardant air barrier, being careful to not seal the combustion air inlet.
- Check the temperature rise of the furnace to ensure that the airflow is not restricted, especially after installation of floor insulation. The temperature rise should be within the range specified on the manufacturer's label or between 40° and 80° F.
- Repair the plenum/furnace joint at the floor before measuring the temperature rise if necessary.
  - If the temperature rise is greater than the recommended range the airflow is restricted by an:
    - Undersized opening in the furnace closet door, or
    - Another restriction in the ductwork
  - If the temperature rise is less than the recommended range, there might be:
    - Significant leakage at the furnace/plenum joint, or
    - Significant leakage in the duct between the furnace and the supply air register where the temperature was measured.
- Room pressures shall be tested once the temperature rise is within the recommended range. See section 115, "Room-to-Room Pressure Test".

411-4-2 Crossover Ducts[3]

Crossover ducts are generally made with flex duct. Inspect crossover ducts for the following conditions and correct as necessary.

- Ducts should not be compressed nor should sharp bends be present.
- Ducts should be insulated to a minimum R8.
- Sags in crossover ducts should be limited to 12 inches over an eight foot span.
- Ducts should be mechanically secured to belly of mobile home.

When replacing a damaged flex crossover duct, use rigid ducts of 26 gauge metal or greater and install a rigid elbow at each end, connecting to the ducts, to allow for better air flow through the duct system. The entire crossover duct must be insulated to R8 (Figure 411-4-2-1).

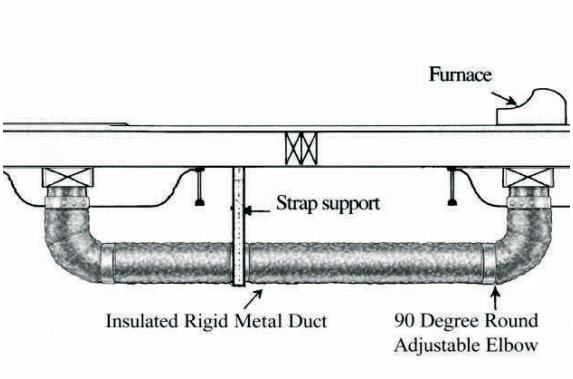


Figure 411-4-2-1: Crossover duct with elbows

411-4-3 Duct Sealing[4]

Any portion of the duct work that extends beyond the last register or grille may be sealed.

End blocks should be made from sheet metal or aluminum flashing. Any metal end blocks must be mechanically attached to the duct system. Gaps between the end block and the duct must be

[3] SWS 5.0105.3, "Crossover Duct Repair or Replacement"
[4] SWS 5.0106.1, "Duct Sealing"

sealed with mastic. If possible, install the trunk end block at least one foot beyond the last register location. Duct "sweeps" or sloped end blocks are not to be used.

Spray polyurethane may be used to seal ducts outside the thermal boundary. Spray polyurethane foam may not be used on ducts inside the thermal boundary.[5]

See section 315-3, "Ducts" for additional information regarding duct sealing procedures and methods for improving airflow.

Duct leakage standards shown in section 411-4-4 shall be met.

411-4-4 Duct Leakage Standards

- No more than half of the pressure-pan readings shall be higher than 3.0 Pa and
- No readings shall be greater than 8.0 Pa (Figure 411-4-4-1).

See section 114, "Pressure Pan Duct Test", for pressure pan test procedures.

Figure 411-4-4-1: Initial pressure pan reading of 47 Pa; return duct was totally disconnected

[5] SWS 5.0106.2c, "Installation"

412 Mobile Home Water Heaters[6, 7]

Mobile home water heaters may be replaced with DOE funds only if the SIR is 1.0 or greater and meets the following requirements.

Water heaters installed at the time of mobile home assembly were HUD approved for mobile home installation (Figure 412-1). The following considerations should be given when replacing mobile home water heaters:

Figure 412-1: Existing mobile home water heater

- Contractors should become familiar with the HUD code for water heaters and apply these standards when advising about, working on, or replacing water heaters in manufactured homes.
- Water heaters, whether gas or electric, should be installed to discourage storage of combustibles around heat-producing appliances. Clearances around water heaters should be in accordance with manufacturer's instructions.
- Gas or propane fired water heaters must provide for the complete separation of the combustion air from the conditioned space. If this condition is met, HUD labeling of the water heater is not critical.
- Water heaters in manufactured homes should be installed with a drain pan.
- Floors under replacement water heaters should be stable, level and structurally sound before they are installed.

[6] For additional information, see "Water Heaters and Manufactured Housing - A Survey of Code Requirements with Recommendations for IHWAP Providers" by the Building Research Council, September 2000.
[7] SWS 7.0302, "Water Heater Installation"

413 Mobile Home Air Sealing

ASHRAE 62.2 shall be used in mobile homes (see sections 112 and 505, "ASHRAE 62.2"). See section 111-2-2, "Target CFM50 Rate" for determining air sealing guidelines.

Because insulating mobile home floors, walls and roof cavities often make a mobile home tighter, it is recommended that air sealing be limited to sealing ductwork and large holes needed to hold insulation in place until all insulation measures have been completed and a blower door test has been conducted.

413-1 Air Leakage Locations

The following are common air leakage problems in mobile homes.

- Plumbing penetrations in floors, walls and ceilings. Water heater closets with exterior doors are particularly serious air-leakage problems, having large openings into the bathroom and other areas.
- Torn or missing underbelly, exposing flaws in the floor to the space beneath the mobile home.
- Gaps around the electrical service panel box, light fixtures, fans and flue pipes.
- Joints between the halves of double-wide mobile homes and between the main dwelling and additions.
- See section 212-4, "Bypass Sealing Materials" for information regarding air sealing materials.

414 Mobile Home Floor Insulation

Mobile home floor insulation is a beneficial measure in heating climates. Existing insulation is fastened to the bottom of the floor joists, leaving the cavity uninsulated and subject to convection currents (Figures 414-1 & 2). Mobile home floor cavities may be blown with fiberglass insulation. Alternate floor insulation methods may be done with IHWAP approval.

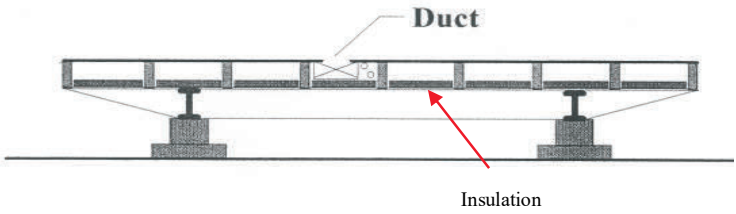


Figure 414-1: Insulation on bottom of floor cavity – floor joists running length of mobile home

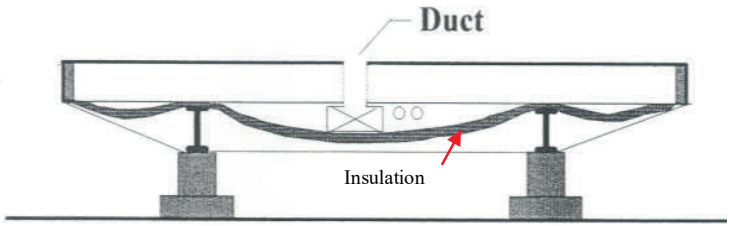


Figure 414-2: Insulation on bottom of floor cavity – floor joists running width of mobile home

414-1 Mobile Home Floor Preparation[8]

- The belly material of the mobile home must be inspected prior to blowing floor insulation. Seal air leaks and ensure that all moisture problems are solved before insulating.
- Gas, water and electrical lines should be secured every 4 feet.
- Ensure that floor cavity is not being used as a belly-return air plenum. The belly-return must be converted to central return before floor cavity is insulated. See section 411-4-1, "Converting Belly-Return Systems".
- If existing conditions of the ground and skirting mandates, a moisture barrier that covers the crawl space ground will may be installed with allowances for structural supports (piers) and

[8] SWS 4.0302.9a, "Pre-work Qualifications"

accessibility. Otherwise, ground moisture barrier is not required for mobile homes.

- Test ducts to ensure that they are tight (see section 411-4, "Ductwork"). Seal all holes in the duct system before insulating floor cavity. Ensure that duct boots are securely fastened to sub-floor and main trunk. Duct leakage standards described in section 411-4-4 should be met.
- Determine location of water pipes in the floor cavity. There must be a minimum of 3 inches between the belly material and pipes for floor insulation. If it is not possible to get 3 inches of floor insulation between the belly material and pipes, the pipes must be insulated or moved closer to the floor above. Otherwise, the floor cavity should not be insulated.
- Tightly seal all holes in the floor to prevent loose insulation from blowing into the living space.
- Seal large holes in the belly material and ensure that all plumbing problems are solved before insulating. Patch holes with insulated foam board, fiberboard, house wrap or belly-paper (nylon reinforced material specially manufactured for mobile homes). Secure patches with stitch-staples and caulk, screws or lath strips.[9] Air and moisture sealing tape such as Force Field from Georgia Pacific or its equivalent is a good secondary means of sealing patches in addition to the mechanical connection. Repairs are aided with the use of one part gun foam to help adhere and seal the repairs.

[9] SWS 3.0102.5 & 7, "MH Belly Repair – Soft Bottom Patching & Rigid Bottom Patching"

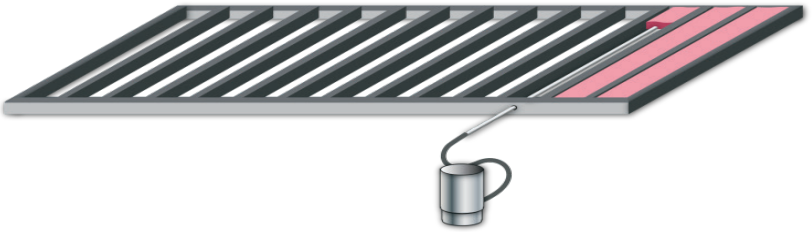


Figure 414-2-1: Insulating floor cavity from the side where the floor joists run crosswise to the mobile home

414-2 Floor Insulation[10]

Floor cavities should be insulated with blown fiberglass installed to a density of 1.25 lbs/ft^3 to 1.75 lbs/ft^3. A density of 1.5 lbs/ft^3 may be achieved if approximately 50 pounds of fiberglass insulation are installed per 100 ft^2 of floor area. Batt insulation may be used when repairing and patching mobile home floor cavities. Blown cellulose and rock wool are not to be used.

Figure 414-2-2: Insulating floor cavity from the end where the floor joists run the length of the mobile home (end blow)

Two methods of insulating mobile home floors are common. The first is drilling through the 2-by-6 rim joist and blowing through a rigid fill tube. Insulation may be blown from the sides where the floor joists run crosswise to the mobile home (Figure 414-2-1), or a side blow. If the floor joists run the length of the mobile home, the floor cavity may be insulated from the ends of the mobile home (Figure 414-2-2), or an end blow.

The second method is blowing insulation through a flexible fill tube from holes in the underbelly (belly-board method).

[10] SWS 4.0302.9, "MH – Blown Belly Insulation"

414-2-1 Side and End Blow Methods

Each joist cavity in the floor is insulated through holes cut in the rim joist. Remove trim pieces to expose the rim joist. Drill carefully to avoid wiring located adjacent to rim joists. Block drilled holes with wood plugs following insulation. Seal plugs with adhesive prior to replacing trim.

Figure 414-2-1-1: Blowing a mobile home floor from the side

Ducts running Crosswise to the Mobile Home (side blow)

Two 2-9/16 inch holes should be drilled into adjacent joist cavities on opposite sides of the mobile home to avoid excessive weakening of the rim joist. The belly-board may have sags in it where it dropped down from the joists, especially near the center where the duct is located. It may be necessary to push the belly-board up and secure to the joists to avoid installing unnecessary amounts of insulation. Leave a minimum 3-inch space between t he belly material and bottom of duct and pipes for insulation.

Ducts running the Length of the Mobile Home (end blow)

The rim joists on the short sides of the mobile home are non-structural. Two 2-9/16 inch holes should be drilled into each cavity at the front and rear of the home as it may be difficult to insulate the entire joist run from one side. Insulate half the cavity from each end of the home.

Attach sections of rigid fill tubes as needed to fill each cavity.

414-2-2 Belly-Board Method

For crosswise joists, use existing holes or cut slits near the center of the home. Extend a flexible fill-tube out to the rim

joist. Fill cavity from edge back towards hole. Repeat procedure on other side of joist cavity.

Secure sections of belly-board to floor joists where sags are present to avoid blowing an unnecessary amount of insulation into the cavity. Leave a minimum 3 inch space between the belly-board and bottom of duct and water pipes for insulation.

For ducts that run the length of the mobile home, cut holes into each joist cavity. Space holes along the floor cavity at approximately the same length as the fill-tube.

415 Mobile Home Wall Insulation

Mobile home walls are usually partially insulated. It is common for the existing insulation to fill only half of the cavity's thickness and to be poorly installed. Access to mobile home walls is from the bottom of the metal siding. Use fiberglass batts or blown fiberglass. Cellulose and rock wool are not allowed because of moisture absorption and weight.

Sidewalls should not be dense-packed or over-filled. Inspect exterior siding and interior panels and repair or reinforce sections as necessary before insulating. Seal holes and cracks in interior wall panels to keep loose insulation from getting into the home.

415-1 Electrical Assessment

The client should be asked about any known existing electrical problems. Assess type and condition of electrical wiring. Electrical #12 aluminum or #14 copper wiring must be protected with 15-amp fuses or breakers. Cavities should not be insulated if excessive movement of the wires will occur. Each outlet, switch, or light fixture should be checked for proper operation with a receptacle tester before and immediately following the completion of the insulation work.

If aluminum wiring is present, a licensed electrician should check that the wiring is safe both prior to and after installing sidewall insulation. A brass pig-tail shall be used to connect aluminum wiring to copper wiring when installing new furnaces, exhaust fans and other electrical devices. Proper ground connections shall also be checked. Contact Weatherization Agency if aluminum wiring is found.

415-2 Wall Insulation

Access to mobile home walls is from the bottom of the siding. If horizontal siding is present, the bottom section of siding is removed. If vertical siding is present, the siding is loosened by removing the bottom row of screws. Joints in the vertical siding pieces may need to be secured with short sheet-metal screws.

Walls may be insulated using the batt-stuffer method or may be blown with fiberglass. Cellulose insulation is not to be used.

415-2-1 Batt-Stuffing Mobile Home Walls[11]

This method works on about 50 percent of metal-sided mobile homes. It is faster than blowing the wall and works well for partially insulated walls or wall cavities with obstructions. Poly encased or vinyl faced fiberglass insulation is preferred for this application, however kraft-faced and unfaced batts will also work (Figure 415-2-1-1).

- Use a batt stuffer made of quarter-inch *Lexan*® (polycarbonate plastic), 10 or 11 inches wide and 96 inches long (Figure 415-2-1-2).
- On the ground, lay a piece of plastic sheeting, measuring approximately

Figure 415-2-1-1: Batt-stuffing a mobile home wall

[11] SWS 4.0202.3, "MH – Fiberglass Batts"

the same size as the unfaced batt and the stuffer.

- Cut batts approximately 8 inches longer than the wall cavity height.
- Lay the batt on the plastic and the batt-stuffer on the batt.
- Lap a few inches of the batt and plastic sheeting over the top of the batt-stuffer. Stuff the batt up into the wall between existing insulation and the interior paneling, with the plastic sheeting against the wall paneling. The plastic sheeting may remain in place.

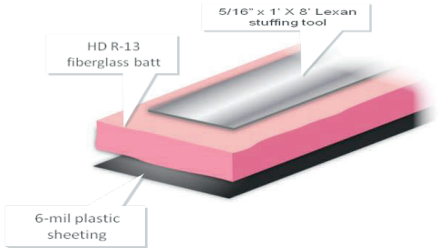


Figure 41521-2: Batt stuffing tool

415-2-2 Blowing Mobile Home Walls[12]

Blowing mobile home wall cavities is recommended for cavities that cannot be stuffed with batts. Additional insulation is blown between existing insulation and interior paneling with a flexible fill tube with a 1-1/4 inch inside diameter. Fiberglass insulation should be blown to a density of no more than 1.6 #/ft^3.[13] The end of the hose should be cut on a 45 degree angle to facilitate movement up the wall cavity. Use the natural curvature of the tube to help push the tube up the wall cavity. Ensure that interior paneling is sound.

- Remove screws from bottom of exterior siding.
- Pull siding and existing insulation away from studs.
- Insert tube to the top of the wall cavity with tip sliding against interior paneling.
- Avoid overfilling the cavity and bulging the exterior siding.

To prevent over-filling the wall cavity, loose blow the bottom of the cavity with an unfaced batt stuffed in the bottom of the cavity to prevent insulation from blowing out of the wall cavity.

[12] SWS 4.0202.4, "MH – Blown Fiberglass"
[13] SWS 4.0202.4e, "Installation"

Additional insulation is blown between existing insulation and interior paneling. Make sure that interior paneling is sound.

416 Mobile Home Roof Cavity Insulation

When insulating mobile homes, blown fiberglass is required. Cellulose is not to be used because of moisture absorption, density and weight.

Figure 416-1: Insulating an older double-wide from the gable end. Courtesy US Dept. of Energy

Insulating mobile homes can be done from the gable, the triangular attic wall area on the narrower sides of the home, below the roof line, and above the ceiling line (Figure 416-1). This approach involves removing the gable siding and cutting a hole through the gable (Figure 416-2). By using scaffolding, this method this method alleviates potential roof damage and is less intrusive than interior drilling methods (Figure 416-3). On average, it should take 15–30 minutes to install and remove scaffolding before and after attic blow. Gable vents can be installed in the hole cut in the siding after the insulation is added to provide future access and additional ventilation.

Figure 416-2: Insulating an older single wide from the gable end. Courtesy US Dept. of Energy

This gable approach can allow more manufactured home candidates to receive attic insulation, reduces labor costs, and improves the SIR compared with other approaches that require

cutting and patching roofs and/or ceiling access holes. This gable approach might also receive less pushback from occupants than when the attic is accessed via holes in the ceiling and/or the roof, which might cause concerns about aesthetics or roof leaks.

Figure 416-3: Insulating a post-HUD mobile home from the gable end. Courtesy US Dept. of Energy

More than one access can be used when encountering a combination of flat and vaulted scissor trusses, inaccessible roof gables or for other unique roof designs (Figure 416-4).

416-1 Preparation

See section 213-1, “Safety”, for information with respect to insulation clearances. Generally, insulation should be kept a minimum of 3 inches from heat producing devices such as non-Type-IC rated recessed lights.

Figure 416-4: Accessing the attic cavity in a mobile home. Courtesy US Dept. of Energy

- Inspect the ceiling and seal all penetrations.
- seal all penetrations.
- Reinforce weak areas in the ceiling.
- Inspect seams and joints on the roof. Seal open seams and joints before or during insulation installation.
- Take steps to maintain safe clearances between insulation and recessed electrical fixtures.

- Assemble patching materials such as metal patches, sheet-metal screws, putty tape, and roof coating.

417 Mobile Home Windows

417-1 Replacement Windows

Replacement windows are to be double glazed.

True mobile home replacement windows shall have a U-value no higher than 0.36 and need not be ENERGY STAR rated. Replacement windows meant for site-built homes but used in mobile homes shall have a U-value no higher than 0.24 and be ENERGY STAR rated.

New jalousie or awning type windows are not acceptable as replacements. At least one replacement window with an emergency release should be installed in bedrooms when a bedroom window is being replaced.

Condition of rough opening members should be inspected when replacing windows. Deteriorated, weak or waterlogged framing members are to be replaced.

Prepare replacement window by lining the perimeter of the inner lip with 1/8-inch thick putty tape or 100% silicone caulk. Exterior window frame perimeter shall be caulked to wall after installing window.

417-2 Mobile Home Storm Windows

Two kinds of interior storm windows are permitted as mobile home measures. RDG storm windows clip into a frame, screwed into the wall. RDG storms serve awning and jalousie windows. Interior sliding storm windows that are paired with exterior sliding prime windows shall be operable. Interior storms shall not interfere with the bedroom egress requirements

Replacement of existing storm windows is not allowed unless the existing storm windows cannot be re-glazed or repaired.

418 Mobile Home Doors

Mobile-home doors come in two basic types: the mobile-home door and the house-type door. Mobile home doors swing outward and house-type doors swing inward. Mobile home replacement doors do not have to be ENERGY STAR rated.

419 Mobile Home Skirting

Mobile home skirting is not allowed either as a retrofit or repair item; however, it may be considered as a WX+ measure if approved by OCA. Insulating existing skirting is also a non-allowable weatherization measure.

500 – Health & Safety Standards

Health and Safety Issues are divided into the following sections:

501 Vermiculite
502 Ambient Carbon Monoxide (CO) Monitoring
503 Spray Polyurethane Foam
504 Mold and Moisture
505 ASHRAE 62.2-2016
- Continuous Exhaust Only
- Supply-Only Ventilation
- Balanced Ventilation

506 Kitchen Exhaust Fans
507 Exhaust Fan Ducts
508 Dryer Venting
509 Gutters and Downspouts
510 Smoke Detectors
511 Fire Extinguishers
512 Carbon Monoxide Alarms
513 Lead Safe Weatherization Practices
514 Code Compliance
515 OSHA
516 Asbestos
517 Hazardous Materials
518 Refrigerants
519 Injury Prevention
520 Radon

Figure 501-1: Vermiculite

501 Vermiculite

Vermiculite is a naturally-occurring mineral composed of shiny flakes, resembling mica (Figure 501-1). When heated to a high temperature, flakes of vermiculite expand as much as 8-30 times their original size. The expanded vermiculite is a light-weight, fire-resistant, and odorless material and has been used in numerous products, including insulation for attics and walls.

A mine near Libby, Montana, was the source of over 70 percent of all vermiculite sold in the United States from 1919 to 1990. There was also a deposit of asbestos at that mine, so the vermiculite from Libby may be contaminated with asbestos. **It should be assumed that vermiculite insulation is from Libby** and the material should be treated as if it contains asbestos.

Attic insulation that looks like vermiculite should not be removed or disturbed. Removal of vermiculite attic insulation is not allowed with any IHWAP funding.

The Weatherization Agency may choose to test for asbestos to determine if insulation and air sealing work can be done. Testing must follow the Asbestos Hazard Emergency Response Act of 1986 sample collection method and testing must be conducted by a certified tester.

Blower door testing is still permitted and should be done in pressurization mode. Therefore, since vermiculite cannot be disturbed, air-sealing cannot be performed in an attic with vermiculite and ventilation may not be installed through such an attic. If it is not possible to comply with ASHRAE ventilation requirements through supply ventilation, balanced ventilation, or exhaust ventilation that goes through a side wall, the home would be a deferral.

502 Ambient Carbon Monoxide (CO) Monitoring

502-1 Requirements

Assessors and final inspectors shall have a designated ambient CO monitor or 4-gas monitor continuously operating while working in the home (Figure 502-1). Monitors are to be worn near the breathing zone (chest or higher).

Figure 502-1: Personal CO monitor

The ambient air shall be sampled upon entering the home. The ambient air may be sampled while taking the initial walk-through of the home. Sampling should be done in all occupiable areas of the home, including basements, utility rooms and attached or tuck-under garages.

Architectural contractors are required to wear personal CO monitors while conducting spillage test-out. Mechanical contractors are required to wear personal CO monitors while conducting Combustion Safety Testing.

Monitors are to be turned on outside the building away from any combustion outlets and automobile traffic areas, adjusted to zero and otherwise prepared for use in accordance with manufacturer's instructions.

Assessors, final inspectors, architectural and mechanical contractors shall comply with CO exposure and Lower Explosion Limits (LEL) action levels specified in section 502-2. Work shall not proceed when CO concentrations in the home exceed 70 ppm or LEL is greater than 10%.

502-2 Indoor Ambient CO Action Levels

Actions in response to ambient CO measurements shall be taken as follows:

- If the CO monitor indicates an ambient CO level of 70 ppm or greater or the LEL reading is greater than 10%, the assessment, architectural work, mechanical work or the final inspection shall immediately cease. The client shall be notified that all building occupants are to evacuate the building. The Weatherization Agency is to be contacted such that the appropriate emergency services can be notified.
- If the CO monitor indicates an ambient CO reading in the range of 36 ppm-69 ppm, the assessor, architectural contractor, mechanical contractor or final inspector shall advise the client that **elevated** levels of ambient CO have been detected. Windows and doors shall be opened. All possible sources of CO are to be turned off immediately. Where it appears that the source of CO is a permanently installed appliance, a recommendation shall be made that the appliance be turned off. Weatherization work not impacted by opening windows and doors or turning off the suspected appliance may proceed. The Weatherization Agency shall be contacted for further direction.
- If the CO monitor indicates an ambient CO reading in the range of 9 ppm-35 ppm, the assessor, architectural contractor, mechanical contractor or final inspector shall advise the client that CO has been detected and recommend that windows and doors be opened. All possible sources of CO should be checked. Where it appears that the source of CO is a permanently installed appliance, the mechanical contractor should be contacted to service the appliance. Weatherization work not impacted by opening windows and doors may proceed. The Weatherization Agency shall be contacted for further direction.

- If the CO monitor indicates an ambient reading in the range of 0 ppm-9 ppm, weatherization work may proceed in a normal fashion.

503 Spray Polyurethane Foam (SPF)

Air purifying masks with an organic vapor cartridge and P-100 particulate filter shall be used when applying low pressure 2-part SPF.

Supply air respirators shall be used when applying high pressure 2-part SPF.

Installer shall have Material Data Sheet (MDS) on site when SPF is being used.

Installers shall follow EPA recommendations when working within a conditioned space or when SPF fumes become evident within the conditioned space. When working outside the building envelope, isolate the area where foam is applied. Precautions are to be taken so that fumes will not transfer to inside the conditioned space. Installers shall check for penetrations in the building envelope during installation and make sensory inspections inside the home for fumes during foam application.

Installers shall inform clients of precautions that may be necessary before using SPF.

504 Mold and Moisture

IHWAP funding cannot be used to remedy severe mold and moisture issues nor can it be used for mold testing.

The following weatherization measures may help eliminate a mold and moisture problems.

- Exhaust fan installation
- Crawl space ground cover
- Attic and sidewall insulation

The following items may also help solve mold and moisture problems and are permitted as either Health & Safety or Incidental Repairs.

- Minor roof repair
- Gutter and downspout work (see section 509, "Gutters and Downspouts")
- Sump pump repair, replacement, installation or covers

505 ASHRAE 62.2-2016

ASHRAE 62.2-2016, *"Ventilation and Acceptable Indoor Air Quality in Residential Buildings"*, defines minimum requirements for mechanical and natural ventilation intended to provide acceptable indoor air quality in all residential buildings.

All architectural and mechanical contractors should familiarize themselves with these requirements. Key points of the Standard are summarized here.

- The ventilation system may consist of continuously operating bathroom and/or kitchen exhaust fans, a supply-only system or a balanced system.
- The required airflow shall be measured following installation of the ventilation system to assure the desired airflow has been achieved. Airflow may be measured with a flow hood, flow grid or other measuring device.
- Accessible override control must be provided to the occupants.

- An on/off switch is not an acceptable override control. Override controls may include, but are not limited to, circuit breaker, flow setting dial on fan or advanced timer control (for meeting the continuous ventilation requirement with intermittent fan operation). Fan control must be clearly labeled as such.
- Information on the ventilation systems and instructions on operation and maintenance shall be provided to the client.

A summary of ventilation systems that may be used to meet ASHRAE 62.2-2016 are included here.

505-1 Exhaust Only Ventilation[1]
All bathroom[2] exhaust fans shall meet the following requirements. See section 506, "Kitchen Exhaust Fans" for kitchen fan requirements.

- ENERGY STAR rated
- Sone rating no higher than 1.0[3]
- Rated for continuous operation
- Fans have an efficacy of 2.8 cfm/watt or more[4]Fans that run on low speed providing the required ventilation with the ability to boost to high speed during period of showering may be used
- Properly terminate the duct to the outside.[5]
- Refer to Table 500-1 for proper exhaust fan duct size

The following installation guidelines shall be met. Note that some bathroom exhaust fans are not to be installed over bathtubs and shower enclosures – check manufacturer's installation guidelines.

[1] See SWS 6.0302.1, "Individual Exhaust Fan Serving Entire Dwelling"
[2] This includes bathroom exhaust fans when installed not to meet the ventilation requirements of ASHRAE 62.2-2016.
[3] Maximum sone rating of 1.1 for interior wall mounted exhaust fans.
[4] SWS 6.0302.1, "Individual Exhaust Fan Serving Entire Dwelling"
[5] SWS 6.0302.1c, "Termination Location"

- Only IC rated exhaust fans may be used such that they may be covered with insulation.
- Fan outlet will be oriented toward the final termination location.
- Fan housing should be securely mounted to ceiling framing members with mounting brackets. Blocking should be added if necessary.
- Fan housing should be flush to ceiling surface.
- Ensure that fan damper closes following duct connector installation.
- Follow manufacturer's wiring diagram. Use proper UL approved connectors to secure housing wiring to fan.
- Fans must be properly grounded.

505-2 Supply-Only Ventilation[6]

A simple supply-only system uses the furnace air handler as the ventilation fan and the heating ducts as the distribution system (Figure 505-2-1). Flex duct is installed from the outside of the home to the return side of the furnace. Whenever the air handler operates, fresh air is drawn in from the outside and mixed with the return air. This system is only permitted when the furnace manufacturer's requirements for return air temperature are met (that is, return air to the furnace is not too cold).

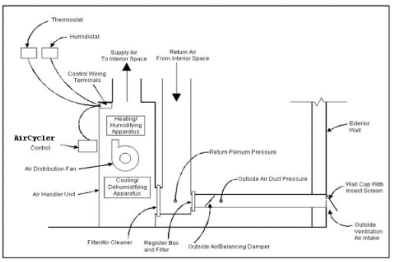


Figure 505-2-1: Supply-only ventilation system

Duct to the outside shall be sized to provide the required ventilation rate. A motorized damper or equivalent

[6] SWS 6.0301, "Supply Ventilation"

technology will be installed between the intake fitting and the return side of the air handler. Air flow will be provided by sequenced operation of the damper or equivalent technology.

Exterior intakes[7] should be located no closer than 10 feet from known sources of contamination such as a stack, dryer vents, bathroom and kitchen exhaust vents and vehicle exhaust. The intake should be placed so that entering air is not obstructed by snow, plantings or other materials. Inlets shall be covered with rodent/insect screens (mesh not larger than ½"). Inform client that inlet must be cleaned of dirt and debris on a regular basis.

Insulated flex duct should be used to reduce condensation during the winter. A filter should be installed between the flex duct and the return duct. Filter should be located and installed in such a manner that allows the client to clean or replace.

505-3 Balanced Ventilation[8]

In tight buildings with limited natural infiltration, a balanced ventilation system can meet the ventilation requirements of a home without creating depressurization or pressurization problems.

Package units can be either heat recovery ventilators (HRV) or energy recovery ventilators (ERV). HRV systems exchange household air with fresh outside air. Sensible heat in the exhausted household air is recovered and transferred to the incoming outside air as both airstreams pass through a heat recovery core. An HRV system is recommended for heating climates when air conditioning is not used in the home.

[7] SWS 6.0101.3, "Exterior Intakes"
[8] SWS 6.0303, "Balanced Ventilation"

An ERV system is recommended when balanced ventilation is installed in a home that has cooling. An ERV system transfers both sensible and latent (heat and moisture) energy. Heat and moisture in the incoming outside air is transferred to the outgoing exhaust air in an ERV so as not to increase the cooling load of a home.

For most effective operation, balanced systems should supply fresh air to all the important living spaces, such as bedrooms, living, dining and family rooms. Exhaust air should be removed from spaces in which moisture and odor are generated, generally kitchens, bathrooms and utility rooms. The duct system should be well-sealed.

The following items should be considered when installing an HRV or ERV system.

- New ductwork should be installed for the HRV or ERV system. If existing ductwork is used, there is a potential that air will "short-circuit" and not circulate around the home. The furnace air handler may be needed to circulate the air around the home. Unless the air handler has an efficient ECM motor, there may be a significant increase in electric consumption.
- HRV and ERV systems require filter cleaning. Units should be located for easy accessibility. Client must be willing to maintain system on a regular basis. Fresh air intake must be cleaned of dirt and debris on a regular basis.
- Condensate will form on the cool side of an HRV during the summer. Provisions for draining the condensate must be provided.
- Fresh air grilles should be located away from sources of poor air quality.
- Balanced ventilation systems should be professionally designed, installed and balanced.

Operation instructions should be posted near the installation to avoid occupant override or misuse.

506 Kitchen Exhaust Fans[9]

Any exhaust fan installed in a kitchen must be rated for kitchen use or installed outside the cooking area (Figure 506-1). Exhaust fans installed in kitchens, other than range hoods, must meet the ventilation requirements of ASHRAE 62.2-2016 and the fan requirements of section 5051, "Continuous Exhaust Only".

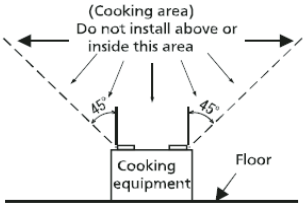


Figure 506-1: Fans used in kitchen must be installed outside the cooking area unless the fan is specifically designed for use in the cooking area

Kitchen range hoods shall meet the following requirements.

- Maximum 3.0 sones
- Have a minimum efficacy of 2.8 cfm/watt
- Should have a minimum exhaust capacity of 100 CFM. Through-the-wall or ceiling mounted exhaust fans may be used when exhaust range hoods cannot be installed.
- Kitchen exhaust fans must be vented to the outside. No recirculating kitchen hoods are permitted to be installed.
- Refer to Table 500-1 for proper exhaust fan duct size.

507 Exhaust Fan Ducts

An improperly vented bathroom or kitchen fan has decreased exhaust capacity because of increased static pressure in the duct. All exhaust fans must be vented to the outside.

- Appropriate exterior termination kits such as wall caps, roof jacks and eave mounted termination vents must be used for bathroom and kitchen exhaust fans.

[9] SWS 6.0201.2, "Kitchen Range Hoods"

- Smooth metal duct or semi rigid flexible aluminum duct may be used. If semi rigid flexible duct is used, the entire length should be supported with braces or hangers every 18 inches to prevent sagging.
- Elbows should be minimized. Elbows with a long radius angle should be used. If possible, there should be a 2 feet to 3 feet horizontal run out of the fan before the first elbow.
- Existing ribbed plastic vent material is not to be used and should be replaced when found. Vent sizes and lengths shall conform to those shown in Table 500-1 given exhaust fan capacities. Note that 3 inch diameter duct is not permitted and that fan ratings are given at 0.25" of static pressure.
- All exhaust fan duct connections shall be sealed with UL 181B or 181B-M listed materials (e.g., mastic, tape).[10]
- Exhaust fan ducts that run through unconditioned spaces must be insulated to a minimum R8 (spray foam insulation may be used).
- Kitchen exhaust fans must be ducted through hard metal and provided with a metal termination cap.

Exhaust Duct Sizing[11]

Table 500-1

Duct Type	Flex Duct				Smooth Duct			
Fan Rating CFM @ 0.25 in. wg	50	80	100	125	50	80	100	125
Diameter (in)	Maximum Length (ft)							
4"	70	3	X	X	105	35	5	X
5"	NL	70	35	20	NL	135	85	55
6"	NL	NL	125	95	NL	NL	NL	145

NL – no limit
X – not allowed

[10] SWS 6.0101.1e, "Sealing" & SWS 6.0101.2f, "Sealing"
[11] From ASHRAE 62.2-2016, "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings"

Table 500-1 assumes no bends and no terminal devices. Subtract the Equivalent Duct Length (EDL) found in Table 500-2 for elbows and terminal devices.

Equivalent Duct Lengths

Table 500-2

	Duct Diameter	
	4”	6”
Elbow	15’	20’
Terminal – Roof Cap	30’	40’
Terminal – Wall Cap	30’	40’

For example, 4 inch smooth duct will be used for a 50 CFM fan (@0.25 in. wc). There will be two elbows and a roof cap. The maximum length without elbows and a roof cap from Table 500-1 is 105 feet. The maximum length of the duct with the elbows and roof cap is 45 feet.

$105' - (2 \times 15'_{\text{elbows}}) - (1 \times 30'_{\text{roof cap}}) = 45'$

Figure 507-1: Fans may not be vented into the attic under the Weatherization Program

It is common to find operating bathroom and kitchen exhaust fans not vented to the outside of the building. The fans may be vented into an attic or crawl space (Figure 507-1). In some cases, the exhaust duct from these fans terminates directly beneath an attic vent (Figure 507-2). Both of these venting options are unacceptable and should be corrected as part of Weatherization.

508 Dryer Venting[12]

Disconnected or improperly vented clothes dryer ducts should be corrected as part of weatherization.

[12] SWS 6.0202.1, “Clothes Dryer”

- Dryer ducts should be smooth-surfaced aluminum or galvanized rigid duct (Figure 508-1).
- Select dryer transition ducts that are no more than 8 feet in total length and contain no joints.
- Rigid transition ducts shall be metal with smooth interior.
- Semi rigid aluminum transition ducts approved for dryer venting may also be used (labeled "Clothes Dryer Transition Duct", UL 2158A).

Figure 507-2: Venting to a roof vent is not allowed under the Weatherization Program; a roof vent may be removed and the exhaust duct extended through the existing hole and capped with a termination kit

- Transition ducts shall not extend beyond the room in which the appliance is located
- Select primary ducts that are rigid, 30-gauge minimum in thickness, non-corrosive, with a smooth interior.
- Mylar covered dryer transition spiral duct may not be used.
- Plastic and vinyl flex duct and smooth plastic pipe are not to be used and must be replaced when found.
- Duct joints should be lapped taking account of the direction of air flow. Duct sections should be connected with foil-backed metallic tape or approved clamps. Screws or fasteners that extend into the duct are not to be used.
- Minimum duct diameter should be 4 inches and length should not exceed

Figure 508-1: Dryers should be vented with smooth metal duct

25 feet from the dryer outlet to the termination point (no more than 8 feet for "Dryer Transition Duct"). If duct length is greater than 25 feet, 5-inch diameter duct should be used. Assume a reduction in maximum length of 2.5 feet for every 45-degree bend and 5 feet for every 90-degree bend. Clothes dryer transition duct should be installed without dips or sags.

- Dryer vent ducts extending through unconditioned spaces are to be insulated to a minimum R8 (spray foam insulation may be used).
- Outdoor dryer vent caps should have a backdraft damper that closes when the dryer is not being used. Insect screens or small wire cages are not to be installed over the vent cap because they can become clogged with lint.

509 Gutters and Downspouts

Missing or damaged gutter systems may be repaired or replaced as a Health & Safety item when necessary to prevent moisture/mold or mildew conditions. The gutter system includes the gutters, downspouts, leaders and splash blocks (Figure 509-1). The following standards shall be met with respect to repairing or replacing gutter systems.

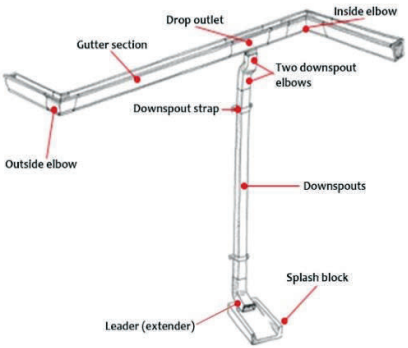


Figure 509-1 Gutter system

- Minimum 0.027 gauge aluminum gutters shall be used. The heavier gauge 0.032 is preferred for heavy ice and snow locations.
- Gutters should be pitched to downspouts at 1/4 inch per 10 feet of run[13]. Short gutters may be hung level. In areas with a

[13] SWS 2.0201.1c, "Slope"

moderate number of trees, gutters and downspouts should be oversized where leaves and debris can be flushed more easily.

- Seal gutter connections with mastic or caulk to prevent leaking.
- Use heavier versions of hangers and secure gutters every 24 inches (18 inches where heavy ice and snow may be a problem). Hangers should be firmly fastened to the fascia, rafter end or truss tails. At a minimum, heavier hangers should be used at stress points, such as corners and downspouts.

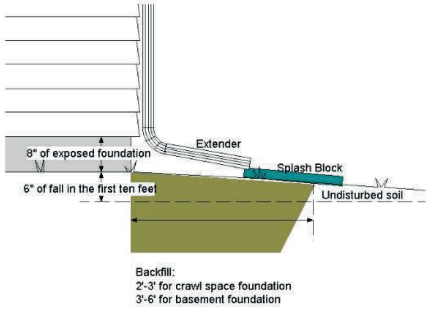


Figure 509-2 Water should be directed away from the home

- Downspouts may be oversized to help reduce clogging. Elbows and straight sections should be fastened together with pop rivets—screws that project into the downspout can lead to clogging.
- Secure downspouts to house with 3 fasteners for every 4 feet of length[14].
- Use 1 downspout for every 40 feet of gutter.

Leaders and splash blocks should be used to direct water away from the home. Water from downspouts should come out at least 3 feet away from a house that has a crawl space and 6 feet away from homes with basements (Figure 509-2).

510 Smoke Detectors[15]

One smoke alarm should be installed on each level of the home. Additional smoke alarms should be installed to ensure that there is one smoke alarm within 15 feet of every room used for sleeping.

[14] SWS 2.0201.2b, "Attachment"
[15] SWS 2.0101.2, "Battery-Operated Smoke Alarms"

When applicable, one additional smoke alarm is installed at the base of the basement stairwell.
Smoke detectors must be installed by the contractor and not left with the client. Select battery-operated smoke alarms that are listed and labeled in accordance with UL 217 and have sealed, non-replaceable, 10-year batteries[16].

510-1 Installation
Install 10-year sealed battery-operated smoke alarms in accordance with the manufacturer's instructions.

Assure that smoke detectors are properly located.

- Smoke detectors should be installed on the ceiling at least six inches from the wall or four to six inches below the ceiling on the wall.
- Install one smoke detector on each level of the home.
- One smoke detector should be located at the base of the basement stairwell.
- One smoke detector should be located within 15 feet of every room used for sleeping.
- Do not locate smoke detectors near kitchen stoves or bathroom showers.
- Do not locate smoke detectors within 12 inches of exterior windows and doors.
- Do not locate smoke detectors in front of supply air registers.
- Exclude unoccupied attics.

Combination smoke and CO detectors are permitted.

510-2 Operation
Test all smoke detectors for proper performance following installation.

[16] SWS 2.0101.2a, “Selection”

Hard-wired smoke detectors[17] should be wired to a circuit that is always energized. They should not be wired to a ground-fault circuit interrupter (GFCI). Hard-wired smoke detectors are to be listed and labeled in accordance with UL 217.

510-3 Client Education

Review smoke detector testing procedures with clients following alarm installation and advise regarding battery replacement as appropriate. Provide occupants the manufacturer's written instructions.

510-4 Specifications

- Smoke detectors that are powered by a battery must emit a signal when the battery is losing power.
- All installation hardware, including a screw mounting bracket, should be included with the alarm.
- Smoke detectors must be approved by Underwriters Laboratories (UL 217).

For additional information regarding smoke detectors, see "Smoke Detector Act (425 ILCS 60/).

511 Fire Extinguishers

Fire extinguishers may only be provided where solid fuel (wood, coal, etc.) is being used in the home as either the primary or secondary heat source. Fire extinguishers must meet the following requirements when provided.

Figure 511-1: Fire extinguisher

Fire extinguishers should be labeled as a combination Class A and Class B and Class C (A-B-C) extinguisher (Figure 511-1). Class A extinguishers

[17] SWS 2.0101.1, "Hardwired (interconnected) Smoke Alarms"

will put out fires from ordinary combustibles such as wood and paper. Class B extinguishers are to be used on fires involving flammable liquids such as grease or gasoline. Class C indicates that the extinguisher may be used on electrical fires. The fire extinguisher must be a minimum of 3lbs. The fire extinguisher should be near the solid fuel burning appliance or in a central location.

Clients should be instructed on use of the fire extinguisher. The term "PASS" may be used for this explanation.

P = PULL the pin (this unlocks the operating handle).
A = AIM the extinguisher at the base of the fire.
S = SQUEEZE the operating handle discharging the fire fighting agent.
S = SWEEP from side to side, carefully moving in on the fire sweeping back and forth across the base of the fire.

512 Carbon Monoxide Alarms[18]

All homes that receive Weatherization work shall receive carbon monoxide alarms regardless of the space heating fuel type.

In addition, carbon monoxide alarms shall be installed, on a permanent basis, when an agency has to delay weatherization services due to an unsafe furnace, water heater, stove, fireplace or oven.

512-1 Type

Combination smoke and CO detectors are permitted.

[18] SWS 2.0102.1, "CO Detection and Warning Equipment"

512-2 Location and Placement

CO alarms must be installed in accordance with the directives of NFPA 72, *National Fire Alarm and Signaling Code*[19], which are as follows:

- A CO alarm must be installed outside of each separate dwelling unit sleeping area, within 21 ft (6.4 m) of any door to a sleeping room, with the distance measured along a path of travel
- On every occupiable level of a dwelling unit, including basements, excluding attics and crawl spaces
- Any room containing fuel-burning equipment, including rooms with a solid fuel (Wood, Coal) burning fireplace
- In other locations where required by applicable laws, codes, or standards.
- Interconnected with smoke alarms where required by code

Do not install alarms in the following areas:

- Near bathrooms or in shower areas,
- In closets,
- Within 5 feet of fuel burning appliances,
- Close to adjacent walls or in corners,
- Near bathtubs or basins,
- Directly above or below return air grilles or supply registers, and
- Behind drapes, furniture, or other objects that could block air flow to the CO alarm.

512-3 Specifications

CO alarms shall:

- Meet or exceed UL2034-98 and/or IAS696 standards.
- Have a manual test and reset button.
- Must contain internal non-replaceable batteries.[20]

[19] National Fire Protection Agency 72 (NFPA 72 (2025), § 29.7)
[20] SWS 2.0102.1a, "Selection"

- Have a ten-year warranty from date of manufacture on the alarm and sensor. Expiration date, as warranted by the manufacturer, must be written on the front of the alarm in permanent ink.
- Be installed in accordance with the manufacturer's instructions

512-4 Client Education

Clients shall be informed about the purpose and features of the CO alarms and tell them what to do if the alarm sounds (Figure 5124-1). Clients shall be given the manufacturer's written instructions.

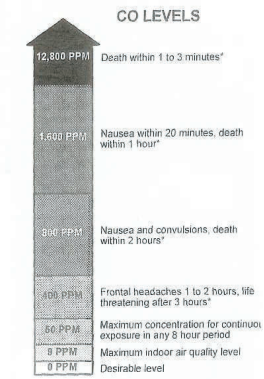


Figure 5124-1: Health effects from elevated CO levels

513 Lead Safe Weatherization Practices

All homes built prior to 1978 are treated as if they have lead-based paint. All work must follow the requirements of the United States Environmental Protection Agency's "Renovation, Repair, and Painting" (RRP) program employing lead-safe methods while working on painted surfaces that are being repaired or retrofitted for energy efficiency.

All contractor weatherization crews must have at least one supervisory worker who has been trained and certified in lead-safe renovation practices under the United States Environmental Protection Agency's RRP program.

Where lead safe work practices are required, their costs may be funded as a health and safety measure. Lead based paint hazard abatement is not allowed with IHWAP Weatherization funding.

Lead safe weatherization consists of work practices that address these two problems:

1. Lead contamination of the work site that may expose children and other residents to lead dust.

2. Protecting weatherization workers from airborne lead dust.

513-1 Dust Control

Lead safe weatherization is all about managing dust. Whenever working with previously painted surfaces, there is a possibility of generating lead dust and paint chips. It is this dust and debris that is a hazard to workers and can become a hazard to residents. There are four essential parts to lead safe weatherization:

1. Generate as little dust and debris as possible
2. Don't breathe it – protect workers when dust is generated
3. Don't spread it – protect the work site and contain the dust
4. Clean up the dust properly

513-2 Engineering Controls

"Engineering Controls" is a term for work practices that limit the amount of dust and debris that is created. Engineering controls help protect workers and the work site from lead exposures. Some helpful engineering controls for weatherization include:

Figure 513-2-1: Use hand tools whenever possible

- Work Wet - when scraping, sweeping, or sanding, misting the surfaces prevents the creation of airborne dust. Simply, the materials become too heavy to get airborne.
- Disassemble rather than demolish. Use hand tools, rather than power tools. Hand tools generate far less dust (Figure 513-2-1).
- If you need to cut a leaded paint surface with a power saw, the line of the cut can be wet scraped clean of paint before starting.
- When drilling through a painted surface, drill through foam shaving cream. This will capture most of the dust and debris generated.

- When taking door and window trim apart, pre-score the joints with a utility knife or window opener to prevent the spread of paint chips around a room.

513-3 Prohibited Practices

The following activities are Prohibited Practices:

- Open flame torches used for paint removal
- Heat guns operating over 1100 F° used for paint removal
- Extensive dry scraping
- Power sanding or grinding (without a HEPA vacuum attachment)
- Uncontained abrasive or water blasting
- Chemical strippers containing methylene chloride

513-4 Resident Protection

Residents are to be informed that Lead Safe Work Practices will be used. Limit access to work areas by instructing the residents to stay away from the work areas. Signs and barriers should be posted if necessary. Resident belongings that can't be moved from the work area should be covered with protective plastic sheeting.

513-5 Worker Protection

Workers are required to wear respirators. Two types of respirators are acceptable: Half mask negative air respirators with HEPA filters (color coded purple) and N-100 paper respirators. All weatherization workers should be "fit tested" and approved for respirator use.

Workers should wear protective clothing. Disposable *Tyvek* coveralls and shoe covers, which can be removed and discarded at the job site, are examples of protective clothing. If this precaution is not taken, workers should vacuum their clothing with a HEPA vacuum before leaving the site.

If workers use the resident's facilities for personal cleanup, these facilities should be thoroughly cleaned at the end of each work day.

513-6 Site Protection

There are three levels of containment for site protection.

- Level 1 Interior Containment – Masking
- Level 2 Interior Containment – Full Room
- Exterior Containment

Note that blowing insulation into attics doesn't disturb painted surfaces (unless access openings need to be cut – Level II Containment). Blowing insulation into sidewalls requires removing siding or exterior finish before blowing insulation. The process of removing the exterior finish or drilling through the sheathing may still cause lead exposure (Exterior Containment).

Level 1 Interior Containment - Masking

For small weatherization tasks that produce some paint chips, but little dust, masking is sufficient. Masking may be used when less than 6 ft^2 of cumulative interior surface will be disturbed.

Typical weatherization tasks requiring Level 1 Containment include:

- Repairing or adjusting a window (not full window replacement)
- Window and door caulking
- Window and door weatherstripping

- Repairing or wet scraping a small section of walls and ceilings

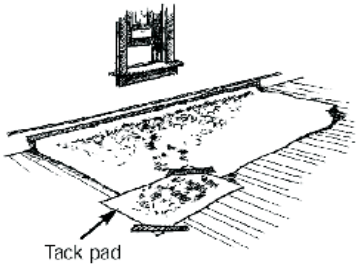


Figure 513-6-1: Level 1 Containment

Masking consists of taping a sheet of 6 mil plastic under the work area. The plastic should extend five feet out from the wall, and five feet in each side direction (Figure 513-6-1). Fabric drop cloths are not to be used as they trap lead dust, and ultimately spread the dust from room to room when the drop cloth is moved.

Level 2 Interior Containment – Full Room

When a weatherization task will generate significant dust and debris or more than 6 ft^2 of cumulative surface is disturbed, that space should be placed under full containment (Figure 513-6-2).

Figure 513-6-2: Level 2 Containment

Weatherization tasks that may require Level 2 Interior Containment can include:

- Window and door replacement
- Cutting access hatches
- Cutting holes for exhaust fans
- Replacing door jambs and thresholds
- Planing a door in place

Full containment consists of removing all the furniture and belongings in a room and covering the entire floor with 6 mil plastic. The door to the room should be fitted with a "slit and flap" opening consisting of two layers of plastic. All vent openings should be sealed.

Figure 513-6-3: Exterior Containment

Exterior Containment (Figure 513-6-3)
It is important to protect the soil around a house from lead contamination when installing sidewall insulation. 6 mil plastic should be secured at the base of the house and extend 10' feet out from the foundation (add five feet for each additional story). The edges of the plastic should be turned up to prevent dust and debris from blowing off the plastic. There should be no open windows or doors within 20 feet of the work site. Work should cease if the wind speed increases to 15 mph.

Ground should still be covered when power tools are being used, even if properly shrouded and connected to a HEPA vacuum.

Respiratory protection is still required when working outdoors.

513-7 Clean Up Procedures
Lead dust cannot be swept up. It is sticky and must be washed up. HEPA vacuums and wet cleaning are recommended.

The cleaning process for lead safe weatherization is as follows:

1. Using a brush attachment on the HEPA vacuum, clean up the visible debris on the plastic.
2. Fold the plastic inward from the corners and place in a plastic disposal bag.
3. HEPA vacuum the entire area – the floor and all horizontal surfaces around the work area.

4. Wet clean the floor and horizontal surfaces. It is best to keep the detergent water in a sprayer to keep the clean water from being contaminated. Wet mop the floor using a separate rinse bucket and twist bucket for the mop. When cleaning other horizontal surfaces (such as window sills and window wells), use a rag with a divided bucket for rinse water and dirty water. Change rinse water regularly.

Examine the work area after cleaning. There should be no visible dust, debris or paint chips.

513-8 Planning and Supplies for Lead Safe Weatherization
Weatherization crews should always have the supplies and equipment available to work lead safe. The supplies should include:

- A HEPA vacuum
- Wash buckets and rags
- Wet mop and mop buckets
- 6 mil plastic and duct tape
- Plastic trash bags
- Respirators for all crew members
- Protective *Tyvek* coveralls
- Shoe covers
- Tack pads

514 Code Compliance

Correction of a preexisting code compliance issue is allowable only if it precludes the installation of a weatherization measure.

Weatherization work will comply with applicable codes in the jurisdiction where the work is being done. Visual inspection at assessment and local code enforcement inspections are used to establish code compliance issues. If code requirements are unclear, consult local code officials for clarification.

515 OSHA

OSHA standards apply to all weatherization contractors. It is the contractor's responsibility to maintain a safe work place and that the employees are properly trained. These standards include, but are not limited to;

- Confined space
- Ladder safety
- Personal protection equipment (PPE)
- Power operated hand tools
- Fall protection

Weatherization workers will follow OSHA Safety Data Sheets (SDS) pursuant to the revised Hazard Communications Standard 29 Code of Federal Regulations 1910.1200 and will take precautions to ensure the health and safety of themselves, other workers and the residents.

516 Asbestos

Abatement and replacement of asbestos containing building components is not allowed with any IHWAP funding.

Removal of siding to install sidewall insulation is permitted. Ducts or pipes wrapped with asbestos are not to be disturbed. Appliance venting containing asbestos should not be disturbed.

In rare cases when asbestos is encapsulating a heating system (usually a boiler), the existing heating system should not be disturbed.

517 Hazardous Materials

All refrigerators, freezers and air conditioning units that are replaced must be removed from clients' homes upon delivery of the replacement units and properly disposed of in accordance with The Clean Air Act, USC Title 42, Section 7671g.

All refrigerators, freezers, and window air conditioning units being replaced must be taken to a recycling facility. Contractors must obtain a certificate or receipt indicating the appliance has been accepted by the recycling facility and provided to the local agency to include in the client file.

518 Refrigerants

Workers handling refrigerants are required to have EPA approved section 608 type I or universal certification.

Refrigerant is to be recovered per the Clean Air Act 1990, section 608, as amended by 40 CFR82, 5/14/93.

The costs of refrigerant handling and safe disposal are included in the costs of the relevant retrofit weatherization measure.

519 Injury Prevention

Minor repairs and installation is allowed only when necessary to effectively weatherize a home.

Repairs for injury prevention, other than when necessary to effectively weatherize a home, are not allowed to be funded with IHWAP funds from any source.

520 Radon[21]

Whenever site conditions permit, exposed dirt must be covered with a vapor barrier (6 mil polyethylene sheeting) except for mobile homes (see section 215-4, “Ground Moisture Barrier”).

Covers must be installed on open sump pits and sealing below grade foundations cracks may also be found as radon mitigation measures[22].

[21] SWS 2.0401, Radon Precautionary Measures
[22] SWS 2.04-1.2, “Sump Well/Pit Covers”

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