



State of Illinois  
Department of Commerce and Economic Opportunity

## WEATHERIZATION

# Illinois Home Weatherization Assistance Program - Field Standards Manual July 2018



*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.*



ILLINOIS DEPARTMENT OF  
COMMERCE AND ECONOMIC OPPORTUNITY

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## 100 – Diagnostic Standards

### 111 Blower Door

#### 1111 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.

- Identify location of the thermal boundaries and house zones that are conditioned (see section 211, “Thermal Boundary”). Check work order for assessor comments regarding any unusual house set-up conditions.
- Deactivate all vented combustion appliances by turning the thermostat down or the appliance off.
- Prevent ashes of wood/coal burning units from entering the living space by closing/sealing doors and dampers or by cleaning out ashes (Figure 1111-1).
- 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 1111-2).
- Close all primary windows, self-storing storm windows, exterior doors and latch them as they normally would be found during the winter.
- Open interior doors so that all indoor areas within the thermal boundary are connected to the blower door.
- 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 1111-1: Ensure that ashes are not drawn into the home during the blower door test**



**Figure 1111-2: Remove a ceiling tile to relieve pressure**

#### 11111 Basements

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 one of the following conditions are present (even if the basement door is generally closed during the winter):

- None of the above mentioned appliances, or ductwork, is in the basement, or



- The occupants do not use the basement on a regular basis; for example, 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, check the work order as the assessor may have noted how the test was done. Call the assessor if necessary.

### 1112 Blower Door Test

The blower door (Figure 1112-1) 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.

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 1112-1: Blower door set-up**

### 11121 Existing Leakage Rate

Conduct a blower door depressurization test to determine the existing CFM50 leakage rate of home. Record the existing CFM50 leakage rate. The average existing leakage rate in Illinois' homes prior to weatherization is about 3900 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 to 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 (done automatically when using the DG700 manometer in PR/FL@50 mode).

#### *Pressurization Test*

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

- Wood or coal fired-heating appliance operating,
- Animal or bird feces is found in the attic that may be a health hazard,

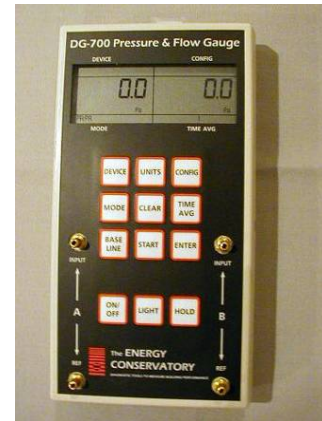
- Hole in top floor ceiling that may result in insulation being pulled into the home,
- Interior wall or ceiling finishes might be pulled down by a depressurization test,
- Open sump in basement,
- Open sewer line in the home, or
- Harmful pollutants could be introduced into the home by the operation of the blower door.
- Presence of suspected asbestos containing material (ACM) such as vermiculite attic insulation which could be drawn into the home during a depressurization test<sup>1</sup>. See section 501, “Vermiculite”.

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 the DG700 manometer (Figure 11122-1) is being used, the CFM50 value shown on the right-hand display will have already been adjusted.



**Figure 11122-1: DG-700 manometer**

#### 11122 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.

A concerted attempt to reach the target CFM50 must be made in every home. The most cost-effective air sealing involves addressing the largest leakage paths first and sealing leaks in the top part of the home. Confirm effectiveness of air sealing strategies by performing intermediate blower door tests.

#### 11123 Intermediate Blower Door Test

Contractors should take “intermediate readings” while doing air sealing work. These readings provide immediate feedback on effectiveness of air sealing work.

<sup>1</sup> SWS 2.0100.10, “Asbestos Containing Materials”

**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

#### 11124 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 plus or minus 10% 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.
- 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 natural draft appliances.

#### 1113 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.

- 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", for additional information).
- Appliance fails spillage test-out (see section 117, "Spillage Test-Out")
- Carbon monoxide levels exceed suggested action levels (see section 3123, "Carbon Monoxide Testing"),
- Evidence of serious mold issues (an area of mold greater than 10 ft<sup>2</sup>) or
- Presence of vermiculite attic insulation which would preclude attic bypass air sealing<sup>2</sup>. 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.

<sup>2</sup> SWS 2.0100.1o, "Asbestos Containing Materials"

#### 1114 Post-Blower Door Test

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

- Inspect all pilot lights of combustion appliances to ensure that blower door testing did not extinguish them.
- Reset thermostats of heating appliances and water heaters that were turned down or off for testing.

#### 112 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.

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 requirements of ASHRAE 62.2-2016. All architectural and mechanical contractors should familiarize themselves with these requirements. A summary of those requirements is provided here.

- Whole house continuous ventilation may be required (includes apartments)
- Required base ventilation is determined by house size and number of bedrooms (Table 100-2) or by number of people living in the home (occupancy)
- Required ventilation must be increased if bathroom and kitchen exhaust fans are not existing or existing exhaust flow rates are insufficient
- Required ventilation may be reduced based on flow rates of existing bathroom and kitchen exhaust fans (fans must be measured to get full credit)
- Required ventilation may be reduced based on the air leakage rate of home as determined by a blower door test

#### 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.

**Table 100-2 Ventilation Air Requirements (CFM)**

Floor Area (ft <sup>2</sup> )	Bedrooms				
	1	2	3	4	5
<500	30	37.5	45	52.5	60
501 - 1000	45	52.5	60	67.5	75
1001 - 1500	60	67.5	75	82.5	90
1501 - 2000	75	82.5	90	97.5	105
2001 - 2500	90	97.5	105	112.5	120
2501 - 3000	105	112.5	120	127.5	135
3001 - 3500	120	127.5	135	142.5	150
3501 - 4000	135	142.5	150	157.5	165
4001 - 4500	150	157.5	165	172.5	180
4501 - 5000	165	172.5	180	187.5	195
5001 - 5500	180	187.5	195	202.5	110
5501 - 6000	195	202.5	210	217.5	225
6001 - 6500	210	217.5	225	232.5	240
6501 - 7000	225	232.5	240	247.5	255
7001 - 7500	240	247.5	255	262.5	270
> 7500	255	262.5	270	277.5	285

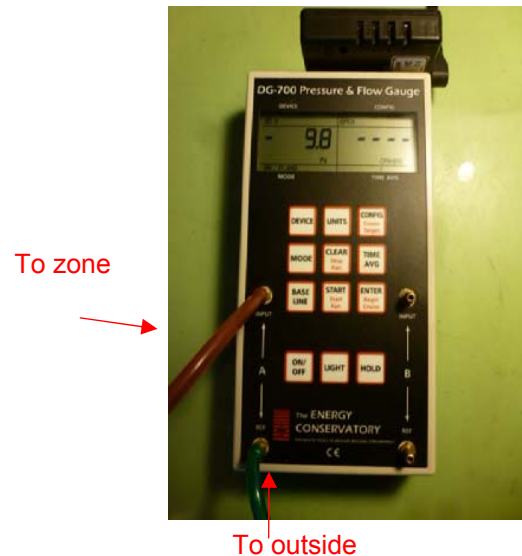
A “zone” is a space that separates a heated space from the outdoors. Typical zones include attics, knee wall spaces, crawl spaces and enclosed garages. The inner boundaries of these zones are building components such as walls, ceilings or floors that separate these zones from the conditioned space. The 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 1131, “Zone-to-Outside Readings”. Zone pressure testing procedures are described in section 11321. The area of the “hole” between the house and the zone can then be determined by “adding a hole”. That procedure is described section 11322, “Add-a-Hole” Method.

#### 1131 Zone-to-Outside Readings

A pressure difference from the zone to the outside is measured 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 air barrier between the living space and zone is tighter than the boundary between the zone and outside (for example, the ceiling is tighter than the roof in an unfinished attic). However, the air barrier (ceiling) should be made tighter if the pressure reading is more negative than -5 Pa.



**Figure 11321-1: Zone pressure measuring attic to the outside**

Zone-to-outside readings of -25 Pa to -50 Pa indicate that the air barrier between the zone and outside is tighter than the air barrier between the living space and zone. For example, the crawl space foundation walls are tighter than the floor between the crawl space and conditioned area. If the crawl space foundation walls are the thermal boundary, holes in the foundation wall should be sealed until the pressure difference between the crawl space and outside is more negative than -45 Pa.

Zone-to-outside readings around -25 Pa indicate that the air barrier between the zone and conditioned space and the air barrier between the zone and outside are equally leaky.

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.

### 1132 Zone Pressure Testing Procedures

Utilize the following procedures for measuring zone pressures (section 11321) and determining leakage areas with the “Add-a-Hole” method (section 11322) in attics, knee wall spaces, crawl spaces and attached or tuck-under garages.

#### 11321 Measuring Zone Pressures

- Identify zones to be measured.
- Set-up blower door for house depressurization 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.
- Record CFM50 of house (CFM50<sub>1</sub>).
- 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.
- Record pressure of zone with reference to the outside - Z/O<sub>1</sub> (Figure 11321-1).
- Compare readings to those shown in Table 100-3.
- Continue with the “Add-a-Hole” Method to determine cumulative hole size.

### 11322 “Add-a-Hole” Method

The “Add-a Hole” Method may be used 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 “ZPD” spreadsheet. The use of the ZPD spreadsheet is described in Appendix 601.

### 1133 Zone Pressure Standards

General thermal boundary (air barrier and insulation) locations and required zone pressure readings following weatherization work are shown in Table 100-3. **If cumulative hole size is less than 20 in<sup>2</sup> (200 CFM50) as determined by the “add-a-hole” method, no air sealing is required regardless of zone pressure reading.**

**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

### 114 Pressure-Pan Duct Test<sup>3</sup>

The pressure-pan test is a duct leakage diagnostic tool that is used with the blower door and digital pressure gauge to identify duct leakage to outside the pressure boundary of the home. 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<sup>4</sup>. A pressure measurement between the duct and the room where the duct register or grille is located provides an indication of whether duct leakage to the outdoors exists (Figure 114-1).



**Figure 114-1: Pressure pan test**

Note that you must first turn off the manometer or push the “CLEAR” button on the DG700 manometer after doing the blower door test to eliminate the “Adjusted Baseline Pressure” before

<sup>3</sup> See SWS 5.3003.3a, “Evaluating Air Flow”. Note that existing testing protocols used in the IHWAP meet the objective of the specification. Use of additional testing equipment as specified in the SWS is not required.

<sup>4</sup> 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.



taking pressure-pan readings. There is no need to use or establish a new baseline as you're simply measuring the pressure difference between the ducts and conditioned space.

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 3122, "Spillage Test"),
  - failed duct-induced pressure test (see section 115, "Duct-Induced 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 home ducts.

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

#### 1141 Pressure-Pan Procedures

- Install blower door and set-up house for winter conditions. Open all interior doors (see section 1111, "House Set-Up").
- Turn furnace off. Remove furnace filter and tape filter slot. Ensure that all grilles, registers and dampers are fully open. If the pressure pan test is being done on a house with ducts in an unconditioned space, seal supply and return air registers in the unconditioned space with tape. If the test is being done on return ducts in a basement, only seal supply registers in the basement but leave return grilles open.
- Temporarily seal any outside fresh-air intakes to the duct system.
- Open attics, crawl spaces that are intended to be outside of the pressure boundary (e.g. vented crawl spaces with insulation under the floor of the house), and garages as much as possible to the outside.
- Close door to basement if testing ducts in basements. If possible, open a basement window or basement door to the outside. Tape the bottom of the basement door to further isolate the basement from the living space if necessary.
- If using DG700 manometer, turn-off to eliminate the "Adjusted Baseline Reading" from the blower door test as noted above. Turn manometer back-on; do not establish a new baseline reading.
- Connect a hose between the pressure-pan and the input tap on the digital manometer. Leave the reference tap open.



**Figure 1141-1: Toe-kick sealed with duct mask tape; pressure pan reading of 24 Pa!**



**Figure 1141-2: Supply air register sealed with duct tape – note pressure pan reading of 23.5 Pa.**



- 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 1141-1) or duct tape (Figure 1141-2). Insert a pressure probe through the duct-mask tape and record reading. Remove tape following reading.



**Figure 1141-3: Sometimes duct leakage is obvious before you use the pressure pan; air coming out of a register with blower door operating; air handler is not on!**

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 1141-3).

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 31532, "Duct Sealing Materials").

#### 1142 Pressure-Pan Standards

Following weatherization work;

- 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.

### 115 Duct-Induced Room Pressure Test

An improperly balanced air-handling system can cause comfort, building durability and indoor air quality problems. 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). This test is required as part of the worst case depressurization test (see section 31212, "House Set-Up").

#### 1151 Duct-Induced 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.

#### 1152 Duct-Induced Standards

Pressure differences greater than +3.0 Pa or more negative than -3.0 Pa should be corrected (Figure 1152-1).

#### 1153 Interpreting Room Pressures

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

To estimate the amount of pressure relief, 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 1153-1).

Transfer areas and ducts are sized based on the equation shown below. If grilles are being installed to correct room pressures, assume that the free ventilation area of the grille is no more than 80% of its total area. To calculate the finished grille size, divide the transfer area – A – by 0.8.

$$A = Q/1.853$$

where:

$A$  = area in square inches

$Q$  = air flow rate (ft<sup>3</sup>/min)

For example, a bedroom supply register has a flow rate of 100 CFM. The free area required for return air is 54 in<sup>2</sup> (100/1.853 = 54). If a transfer grille is to be installed between the bedroom and hallway, the area of the grille should be at least 68 in<sup>2</sup> (54/0.8 = 68).



**Figure 1152-1: Duct induced room pressure is 18.5 Pa!**



**Figure 1153-1: Jumper duct installed in attic connecting bedroom to hallway (Courtesy Southface Institute)**

## 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 digital manometer (Figure 116-1). This test must be done to confirm flow rates if exhaust fans are used to meet ASHRAE 62.2.

### 1161 Exhaust Fan Flow Meter Procedures

- Press the MODE button once. Pressure (Pa) will be displayed on the A channel and flow (CFM) will be displayed on the B channel.
- Press the DEVICE button five times until EXH is displayed above the A channel display. EXH is the acronym for Exhaust Fan Flow Hood.
- Press the CONFIG button once. B2 will be shown above the B channel display. Be sure the opening on the flow hood is open to the E2 position.
- Connect both input taps using a bridge hose. Connect another hose from the T-connector to the exhaust fan flow hood (Figure 1161-1).
- Make sure the door opening on flow meter is set to E2.
- Place flow meter completely over fan forming an air-tight seal (flow meter will not work for kitchen exhaust hoods).
- Turn-on exhaust fan. After 10 seconds, read both Pressure (A channel) and “Flow” (B channel) readings on manometer.
- Ensure readings by comparing them to those on the side of the flow hood.
- If pressure reading (A channel) on manometer is greater than 8.0 Pa, select a larger opening on the flow meter. If E1 is already being used (the largest opening), the fan exhaust is outside the upper range of the flow meter (124 CFM).
- If the flow reading (B channel) on the manometer reads “LO”, select a smaller opening on the flow meter. If E3 is already being used (the smallest opening), the fan exhaust is below the lower range of the flow meter (10 CFM).
- When changing the opening on the flow hood, be sure to change the configuration on the manometer using the CONFIG button.

The manometer and exhaust fan flow hood set-up for measuring exhaust fans is shown in Figure 1161-2.



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



**Figure 1161-1: Manometer set-up for exhaust fan flow hood**



**Figure 1161-2: Manometer and exhaust fan flow hood – flow hood is set to the E2 opening**

## 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 natural draft appliance venting. This test is only required for natural draft appliances.

If ambient CO levels equal or exceed 9 ppm, see section 502-2, “Indoor Ambient CO Action Levels”, for additional guidance.

Note that this test is required following completion of work every day – not only at job completion<sup>5</sup>.

1. Close all windows and exterior doors. Close fireplace damper.
2. Close all interior doors, including door to combustion appliance zone (CAZ)<sup>6</sup>. Leave doors to rooms open:
  - with exhaust fans, such as bathrooms and kitchens, open, or
  - ducted returns.
3. Turn on clothes dryer. Turn on all exhaust fans, such as bathroom and kitchen exhaust fans, such that they operate at maximum speed. Do not turn on whole house fans.
4. Turn on furnace air handler.
5. Turn-on natural draft appliance. Test for spillage at the draft diverter or draft hood with a mirror or smoke pencil.
6. Check for spillage<sup>7</sup> –

### *Natural Draft 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).

### *Natural Draft Furnaces - Warm Vent (when furnace thermostat is on heat) –*

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

### *Natural Draft Furnaces - Cold Vent (when furnace thermostat is not on heat) –*

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 and open window if possible.



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



**Figure 117-2: Failed spillage test**

<sup>5</sup> See SWS 2.0201.1i, “Combustion Appliance Zone Testing”

<sup>6</sup> CAZ is the space in which the natural draft appliance is located.

<sup>7</sup> ANSI/BPI-1200-S-2017, “Standard Practice for Basic Analysis of Buildings”, sections 7.9.2 and 7.9.3

Check for blocked flue or chimney. If blockage is found and removed, repeat spillage test. Also see section 3124, “Solutions to Combustion Safety Testing Failures”. Any appliance that fails spillage test-out may not be left in that condition<sup>8</sup>.

7. Ambient CO will be monitored during combustion testing. If ambient CO levels equal or exceed 9 ppm, see section 502-2, “Indoor Ambient CO Action Levels”, for additional guidance.

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<sup>8</sup> See SWS 2.0201.1f, “Spillage Test”

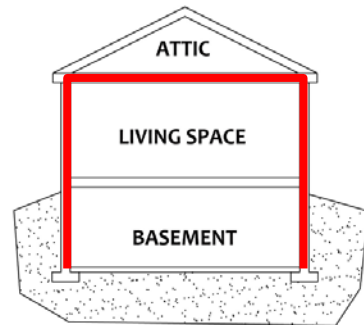


## 200 – Architectural Standards

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.

### 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: 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 11111, "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 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 very 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.

### 2121 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 reading to the agency, and
- Conduct Spillage Test-Out procedure



**Figure 2121-1: Smoke being drawn down an open study cavity indicating leakage to the inside**

**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 2121-1). 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.

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 11123, “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 11124, “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”)<sup>1</sup>.**

## 2122 Sealing Bypasses

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.



**Figure 2122-1: Sealing joist cavity under knee wall with foam board and 2-part spray foam**

<sup>1</sup> See SWS 2.0201.1i, “Combustion Appliance Zone Testing”



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, a chaseway in a plumbing wall tightly sealed from the house but very leaky to the attic acts as an insulation bypass without leaking air between the house and the attic. Even though the house air leakage may not be reduced, the attic insulation performance will improve after this attic bypass is sealed<sup>2</sup>.

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 attached with mechanical and/or adhesive bonds. 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 insulation into surrounding cavities so that the cellulose will resist airflow and clog cracks between building materials (see section 2142, "Dense-Packed Wall Insulation - Cellulose").

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

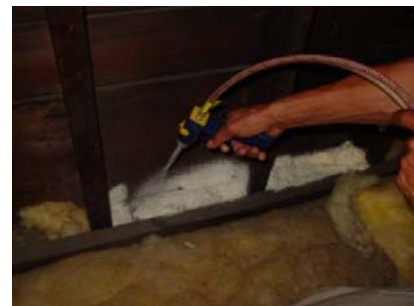
- **Joist spaces under knee walls in finished attic areas:** Connect knee wall air barriers on two floors by creating a rigid seal under the knee wall in one of two ways.
  - Install minimum 1 inch thick rigid foam board insulation blocks between ceiling joists. The perimeter of the foam blocks should be sealed with two-part foam (Figure 2122-1), 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.
- Kitchen or bathroom interior soffits: Seal the top of the soffit with plywood, gypsum board or rigid foam board insulation: fasten and seal to ceiling joists and soffit framing with two-part spray foam (Figure 2122-2)<sup>3</sup>.
- **Two-level attics in split-level houses:**
  - Seal the wall cavity with a rigid material fastened to studs and wall material, or



**Figure 2122-2: Soffit sealed with foam board and 2-part spray foam**



**Figure 2122-3: Stud cavity sealed with 2-part spray foam**



**Figure 2122-4: Study cavity blocked with batt insulation and sealed with 2-part spray foam**



**Figure 2122-5: Balloon framed stud cavity sealed with fiberglass batts stuffed in cellulose insulation bags**

<sup>2</sup> See SWS 3.1001.1, "Penetrations and Chases"

<sup>3</sup> See SWS 3.1003.1, 2 & 3, "Dropped Ceilings and Soffits"

- Block stud cavity with scrap batt insulation and cover with 2-part spray foam (Figures 2122-3 & 2122-4), 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 2122-5) 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 2122-5), or
  - 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<sup>4</sup>.
- **Fur cavity in masonry buildings:** Seal cavity with one or two-part foam around perimeter of attic/roof cavity (Figure 2122-6).
- **Chimney passing through attic floor:** 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 (Figure 2122-7). 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
  - 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 2122-8).
- **Soil stacks, plumbing vents, open plumbing walls:** Seal joints with two-part foam or caulk. If joint is too large, stuff with fiberglass insulation or seal with rigid foam board and foam over the top (Figure 2122-9).



**Figure 2122-6: Fur cavity sealed with 2-part spray foam**



**Figure 2122-7: Seal chimney bypass with sheet metal and high temperature sealant**



**Figure 2122-8: Cut-off chimney in attic**



**Figure 2122-9: Plumbing wall cavity sealed with foam board and 2-part spray foam**

<sup>4</sup> See SWS 3.1001.3, “Walls Open to Attic – Balloon Framing and Double Walls

- **Housings of existing exhaust fans and recessed lights:** Caulk joints where housing meets the ceiling (see section 2131, “Attic Insulation Safety” for boxing and air sealing around recessed lights and exhaust fan housings<sup>5</sup>).
- **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 2122-10). Smaller openings may be foamed or stuffed and caulked<sup>6</sup>.
- **Joists between floors:** Air seal perimeter of building at bandjoist areas with dense-pack cellulose or fiberglass.
- **Bathtubs and shower stalls:** Seal 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 2122-11).
- **Attic hatches and stairwell drops:** See section 2135, “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 string (Figure 2122-12); extend gun to top plate and seal (Figure 2122-13).
- **Other openings in the air barrier:** Seal with rigid material, two-part foam, one-part foam or caulk depending upon size of opening.



**Figure 2122-10: Duct chase sealed with foam board and 2-part spray foam**



**Figure 2122-11: Cavity beneath bathtub sealed with gypsum board and dense-packed with cellulose**



**Figure 2122-12: 2-part spray foam gun secured to broom stick with string attached to handle**

### 2123 Bypass Sealing Materials

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

<sup>5</sup> 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”).

<sup>6</sup> See SWS 3.1001.4, “General Penetrations”



### 21231 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<sup>7</sup>.

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<sup>8</sup>.

### 21232 Spray Foams

Spray foams are not permitted to be used in the living area of home. Spray foams may only 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 21232-1)
  - **1-part foam dispensed through plastic nozzles is not permitted (Figure 21232-2).** 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 25 or less.



**Figure 2122-13: Exterior wall top plate under low-pitch roof sealed with foam gun shown in Figure 2122-10.**



**Figure 21232-1: 1-part spray foam; foam canister is screwed onto a foam gun**



**Figure 21232-2: 1-part spray foam dispensed through a plastic straw is not permitted in the Weatherization Program**

<sup>7</sup> See SWS 2.0100.1c

<sup>8</sup> See SWS 2.0100.1i

- 2-Part Foam (Figure 21232-3)
  - 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 25 or less.



**Figure 21232-3: 2-part spray foam**

### 21233 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 1/2 inch of the surface with an appropriate packing material specifically manufactured as a packing material prior to caulking<sup>9</sup>. 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

### 21234 Packing Materials

Packing materials used to fill gaps too large for caulks or sealants to seal properly must be flexible closed cell or otherwise nonporous materials that will not absorb moisture and will remain flexible at low temperatures. Packing materials include flexible polyurethane, oakum, butyl rod or similar foam rod stock.

Fiberglass is not to be used as an air sealing material, but may be used to stuff larger openings as a backer material with spray foam applied over the top of it. Tops of open wall cavities may also be stuffed with fiberglass which will be dense-packed with insulation.

### 21235 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

<sup>9</sup> See SWS 3.1001.4c, "Sealant Selection"

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.

## 2124 General Air Sealing

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 (chaseways) in the basement/crawl space with a heat resistant material (flashing, gypsum board, etc.) and seal with a compatible sealant.

## 213 Attic Insulation

### 2131 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 2131-1). 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. If there is insufficient clearance to install a box 4 inches higher than the insulation, do not cover the box and use an appropriate barrier to keep the insulation 3 inches away from the fixture<sup>10</sup>.



**Figure 2131-1: Recessed light covered with drywall box**

<sup>10</sup> See SWS 4.1001.1, “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<sup>11</sup>.
- 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 regardless if fixture is IC rated.<sup>12</sup>
- 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 chimneys and metal flues with 26 gauge galvanized metal sealed with high temperature caulk to chimney or vent and surrounding framing materials (Figure 2131-2). A “fire block” spray foam is not permitted for this application. Vertical metal used as a barrier around heat producing devices or chimneys must be fastened securely to attic joists in such a manner as to not allow the barrier to collapse when insulation is installed (Figure 2131-3)<sup>13</sup>. A minimum 3 inch clearance shall be maintained between barrier and chimney or heat producing device and shall extend a minimum of 3 inches above the finished level of the attic insulation.
- 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.



**Figure 2131-2: Metal barrier around flue sealed with high temperature caulk**



**Figure 2131-3: Metal barrier around chimney**

<sup>11</sup> To prevent condensation within the box

<sup>12</sup> See SWS 4.1005.7c, “Attic Floor – Preparation and Installation of Spray Polyurethane Foam”.

<sup>13</sup> See SWS 4.1001.3, “Fireplace Chimney and Combustion Flue Vents”



- Install insulation beneath active knob-and-tube maintaining a one-inch air space between insulation and wiring (Figure 2131-4). Alternately, non-metallic channels or barriers, such as rigid foam board, should be installed to maintain minimum one-inch air space alongside of knob-and-tube wiring (Figure 2131-5)<sup>14</sup>.
- Frayed wiring must be repaired 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<sup>15</sup>.
- 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 2131-4: Attic insulation installed under knob-and-tube wiring**



**Figure 2131-5: Rigid foam board used as barrier next to K&T wiring; floor cavity will be blown with cellulose insulation**

## 2132 Attic Insulation Preparation

### 21321 Bypasses

Air leakage and convection 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 2121, “Testing”).**

### 21322 Roof Leaks

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

### 21323 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 an 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”<sup>16</sup>.

<sup>14</sup> See SWS 4.1001.2, “Knob and Tube Wiring” & 2.0601.1c, “Knob and Tube Wiring”. A variance has been granted that a licensed electrical contractor does not have to inspect the wiring.

<sup>15</sup> See SWS 4.1005.2a, “Accessible Attics – Loose Fill Insulation”

<sup>16</sup> See SWS 6.6003.1, “Surface Mounted Ducted”.



## 21324 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.

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 21324-1). Cavity may be blocked with two-part spray foam (Figure 2122-13), rolled fiberglass insulation or other rigid materials<sup>17</sup>. Chutes must be long enough to extend above the level of the finished insulation (Figure 21324-2)<sup>18</sup>.

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

In rafter cavities where a chute 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.

Soffit chutes are installed only where soffit vents are present. For continuously vented soffit, one soffit chute shall be installed for every three rafter cavities.

## 2133 Unfinished Attics

### 21331 Blowing Attic Insulation

It is recommended that blown insulation be used instead of batt insulation whenever possible because blown insulation forms a seamless blanket.

Attic insulation shall achieve a total R-value of 49 or the maximum amount with an SIR greater than 1.0 on the work order (Figure 21331-1).

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 21331-2). At a



**Figure 21324-1: Foam blocking installed over top plates**



**Figure 21324-2: Soffit chutes extended above insulation**



**Figure 21331-1: Required attic insulation R-value is a minimum of 49 or the maximum amount with an SIR greater than 1.0**



**Figure 21331-2: Attic insulation marker**

<sup>17</sup> See SWS 3.1001.3, "Walls Open to Attic"

<sup>18</sup> See SWS 4.1001.4, "Vented Eave of Soffit Baffles"

minimum, one marker shall be installed for every 300 ft<sup>2</sup> 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.

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<sup>19</sup> and be reduced by half when the attic temperature is -8°F<sup>20</sup>. 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<sup>21</sup>.

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 to 4.00 lbs/ft<sup>3</sup>. Access these areas by drilling or removing the fascia board and tube filling each cavity. Ventilation is not needed when dense packing flat roofs.

### 21332 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 to 4.00 lbs/ft<sup>3</sup>. 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 chemical smoke at 50 pascals of pressure difference.

Insulation may be blown over flooring with client’s permission. Blowing insulation over the flooring may be done in addition to



**Figure 21332-1: Insulation blown under floor boards and then over floor boards where client storage is not needed**

<sup>19</sup> Building Research Council, University of Illinois at Urbana-Champaign, 1991

<sup>20</sup> “Convective Loss in Loose-Fill Attic Insulation”, Oak Ridge National Laboratory, 1992

<sup>21</sup> See SWS 4.1005.2, “Accessible Floors – Loose Fill Insulation”

blowing the floor cavity – not in lieu of blowing the floor cavity (Figure 21332-1)<sup>22</sup>.

### 21333 Batt Insulation

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 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.

### 2134 Cathedral Ceilings

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 and 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 to 4.00 lbs/ft<sup>3</sup>. Blown fiberglass must be blown to a minimum density of 2.25 pounds per cubic foot 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.

### 2135 Attic Access Hatches

Install permanent blocking around the attic access hatch. Use rigid materials such as plywood that will support 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 adjoining assembly with foam board insulation – hatches are not to be insulated with batt insulation (Figure 2135-1).



**Figure 2135-1: Attic hatch insulated with foam board; plywood blocking has been insulated with foam board**

<sup>22</sup> See SWS 4.1005.6, “Enclosed Attic Storage Platform Floor – Dense Pack Insulation”

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.

Attic hatches must not be permanently sealed<sup>23</sup>.

A box shall be built and installed over retractable attic stairways

(Figure 2135-2)<sup>24</sup> Hatches will 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.

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 2135-3) as well as the cavity beneath the stairs. Install threshold or door sweep and weatherstrip door.

Dense-pack cellulose insulation should also be blown into the cavity beneath the stair treads and risers. Determine if blocking exists to stop insulation from filling other areas by mistake when planning to insulate walls and stairway.

## 2136 Finished Attics

The finished attic consists of five sections (Figure 2136-1).

- 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)

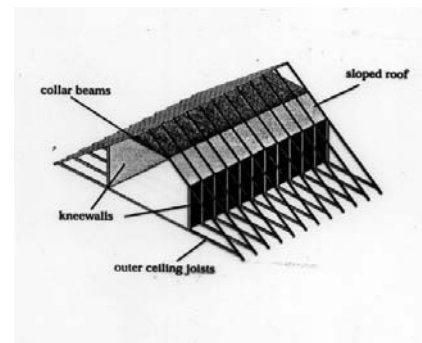
Attic bypasses shall be sealed before insulating.



**Figure 2135-2: Box around retractable attic stairs**



**Figure 2135-3: Stairwell walls being dense-packed**



**Figure 2136-1 Attic sections**

<sup>23</sup> See SWS 4.1006.2, "Access Doors and Hatches"

<sup>24</sup> See SWS 4.1006.1, "Pull-Down Stairs"



### 21361 Exterior Finished Attic Walls

Insulate exterior finished attic walls per section 214, “Wall Insulation”.

### 21362 Collar Beams & Outer Ceiling Joists

Insulate collar beams and outer ceiling joists per section 2133, “Unfinished Attics”.

### 21363 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 to 4.00 lbs/ft<sup>3</sup>.

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.

### 21364 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 rather than the knee walls. See “Knee Wall within Conditioned Space”.

#### *Open Cavity – Single Batt*

Insulate knee walls with maximum R-value as allowed by stud cavity depth (Figure 21364-1). Extend batt insulation down to bottom plate of knee wall. Ensure that joist cavity beneath knee wall has been air sealed (see section 2122, “Sealing Bypasses”). Insulation shall fit snugly between the studs.

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, “belly patch” or ½ inch insulated foam sheathing may be used to cover the insulation (Figure 21364-2)<sup>25</sup>.



**Figure 21364-1: Knee walls insulated with fiberglass insulation**



**Figure 21364-2: Fiberglass insulation covered with foam board used as an air barrier**

<sup>25</sup> See SWS 4.1004.2, “Preparation for Batt Insulation”

### *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 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*

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. However, insulation shall be covered with a fired-rated material if required by local code<sup>26</sup>.

### *Open Cavity - Dense Packed*

Close-in knee wall studs with house wrap material, “belly-patch” or 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.

Cut holes in knee wall material and insulate with dense pack cellulose (3.5-4.0 lbs/ft<sup>3</sup>) – Figure 21364-3<sup>27</sup>.



**Figure 21364-3: Knee walls being dense-packed with cellulose**

### *Closed Cavity - Knee Wall*

Insulate closed cavity knee walls per section 214, “Wall Insulation”.

<sup>26</sup> See SWS 4.1004.5, “Knee Walls and Gable End Walls – Preparation for and Installation of Spray Polyurethane Foam (SPF)”

<sup>27</sup> See SWS 4.1004.1, “Preparation for Dense Packing”

### *Knee Wall within Conditioned Space*

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 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.



**Figure 21364-4: Connecting roof thermal boundary to sidewall thermal boundary with rigid foam board insulation; 2-part spray foam will also work**

### 21365 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.



**Figure 21365-1: Knee wall hatch insulated and weatherstripped**

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 21365-1). A new access cover of a durable rigid material should be installed if necessary<sup>28</sup>.

### 2137 Attic Venting<sup>29, 30</sup>

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.

<sup>28</sup> See SWS 4.1006.2, "Access Doors and Hatches".

<sup>29</sup> 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.

<sup>30</sup> See SWS 4.1088.1, "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.

#### 21371 Existing Vents

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

#### 21372 New Vents

If attic ventilation is to be installed, the vents shall be installed so there are equal amounts of low intake vents through soffit or eaves and higher exit vents on the roof. All separate attic spaces are to be cross-ventilated with one inlet and one outlet vent.

#### 21373 Low/High Venting

Low (intake) vents should be placed at a minimum of 12 inches above the finished level of attic insulation. Eave chutes or baffles should be provided over top plates where soffit and other low vents could cause blowing of loose fill insulation. See section 21324, “Top Plates”.

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

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

#### 21374 Soffit Vents

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

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

#### 21375 Gable Vents

Gable end vents shall be installed as high in the gable end as possible and above the level of the attic insulation. Existing gable vents should be boxed if insulation comes up to the bottom of the vent.



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

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

If gable vents are prone to wind driven rain or snow entry, exterior baffles shall be installed.

#### 21376 Roof Vents

Roof vents should never be installed on a roof that is in poor condition.

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

Turbine vents may only be used as exhaust vents, i.e., in conjunction with soffit, gable or roof vents.

Attic powered ventilators are not to be used<sup>31</sup>.

#### 21377 Ridge Vents

Pre-fabricated aluminum ridge vents are not permitted. Only ridge vents that can be capped with shingles are to be installed. Manufacturer's installation recommendations shall be followed, especially with regards to the presence of a ridge board and terminating cuts from end walls and hip and ridge intersections. Roof shingles and sheathing shall be cut without cutting roof rafters. Ridge cap shingles shall be installed according to shingle manufacturer's instructions.

#### 2138 Attic Insulation Certificate

Contractors and crews installing blown-in insulation must permanently fasten to the roof side of the attic access (or other accessible location specified by the Weatherization Agency) a signed certificate that attests to the company name, date installed, insulation brand name, R-value added, square footage, thermal resistance chart, conformance to federal specifications and the number of bags installed in the attic<sup>32</sup>.



**Figure 2138-1: Attic insulation marker**

Attic insulation markers shall be placed in locations throughout the attic such that insulation depth and uniformity of coverage can be inspected (Figure 2138-1). At a minimum, one marker shall be installed for every 300 ft<sup>2</sup> throughout the

<sup>31</sup> See SWS 4.1088.1, "Attic Ventilation"

<sup>32</sup> See SWS 4.1006.2e, "Access Doors and Hatches – Occupant Education"

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.

## **214 Wall Insulation**

### **2141 Wall Insulation Preparation<sup>33</sup>**

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 external 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 2141-1). 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 must be finished and returned to condition as close to original as possible.
- Wall cavities must be probed to identify fire blocking, diagonal bracing and 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 will 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.



**Figure 2141-1: Asbestos siding that has been removed**

### **2142 Dense-Packed Wall Insulation - Cellulose<sup>34</sup>**

- Contractors and crews installing dense-packed cellulose wall insulation must be certified to do so by the Illinois Weatherization Program.<sup>35</sup>

<sup>33</sup> See SWS 4.1101.1, "Exterior Wall Dense Packing"

<sup>34</sup> See SWS 4.1103.1, "Dense Pack Exterior Walls"

<sup>35</sup> 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.

- 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 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 2142-1). 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<sup>36</sup>.
- 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 2142-2). Attach with minimum two staples to hold in place.
- Dense pack insulation will be verified to prevent visible air flow at 50 pascals of pressure difference.



**Figure 2142-1: Dense-pack cellulose being installed**



**Figure 2142-2: Hole sealed with sheathing tape**

### 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.

<sup>36</sup> 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.

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.

#### 2143 Dense-Packed Wall Insulation – Fiberglass<sup>37</sup>

- Contractors and crews installing dense-packed fiberglass wall insulation must be certified to do so by the insulation manufacturer.
- Access to wood frame sidewalls shall be per section 2141, "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.
- 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 1/4 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 holes with tapered wood plugs. Seal the plug to sheathing to maintain water seal integrity with caulk or other suitable patching material.

#### 2144 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 2141, "Wall Insulation Preparation".
- Install insulation in accordance with the manufacturer's recommended application procedures (Figures 2144-1 and 2).
- Wall cavities shall be completely filled with no voids or gaps.
- Walls with existing batt insulation may be insulated with injection foam.



**Figure 2144-1: Injection foam being used to insulate wood frame wall**

<sup>37</sup> See DSWS 4.1101.1, "Exterior Wall Dense Packing"



- Seal holes with plastic, foam or wood plugs. Seal the plugs to sheathing to maintain water seal integrity with caulk or other suitable patching material (Figure 2144-3).

#### 2145 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 2141, “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 2141, “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 (Figure 2145-1).
- 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 90° 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 bandjoist) should be completely filled with insulation. Insert rigid fill tube half the width of the cavity. Pack the joist cavity with insulation.

#### 2146 Open-Cavity Wall Insulation<sup>38</sup>

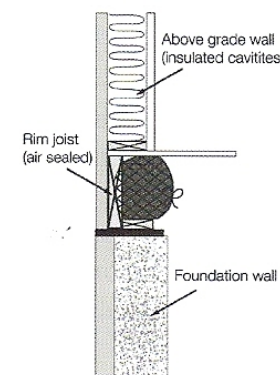
Batt insulation must be cut to the exact length of the cavity. Each wall cavity should be completely filled with batt insulation.



**Figure 2144-2: Injection foam used to insulate brick veneer wall**



**Figure 2144-3: Holes sealed with foam plugs**



**Figure 2145-1: *Insul-Bag* used to insulate bandjoist.**

<sup>38</sup> See SWS 4.1102, “Accessible Walls”

- 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 barrier 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.

#### 2147 Completion of Wall Insulation

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<sup>39</sup>.

### 215 Crawl Space Insulation

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 2154, “Ground Moisture Barrier”, for exceptions.)

#### 2151 Crawl Space Foundation Insulation<sup>40</sup>

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.

Foundation wall insulation shall be a minimum R10 and should extend from the top of the foundation wall down to the crawl space floor.

Extruded polystyrene and polyisocyanurate insulation are the most appropriate insulation types for flat concrete or concrete block walls (Figure 2151-1). Two-part foam is also an option for insulating foundation walls and care must be taken to assure that the proper thickness is obtained (Figure 2151-2). **Fibrous insulation is not to be used for foundation wall insulation.**

<sup>39</sup> See SWS 4.1103.2f, “Additional Exterior Wall Cavities – Onsite Documentation”

<sup>40</sup> See SWS 4.1402.1, “Closed Crawl Spaces – Wall Insulation”



Concrete block walls foundation walls may also be insulated with injection foam. Injection foam insulation shall have a minimum R-value of 4.4 per inch. Access to block cores shall be gained by drilling through mortar joints or through cores at the top of the foundation wall. Cores shall be completely filled with insulation. Contractors and crews installing injection foam insulation in concrete block walls must be certified to do so by the insulation manufacturer. No additional foundation wall insulation is required if injection foam insulation is used.

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 2154, “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.
- Overlap seams at least 12 inches using reverse or upslope lapping technique<sup>41</sup> and seal with acoustical sealant or 3M #8086 builders’ tape or equivalent.
- Insulation should be attached to the entire wall surface with appropriate fasteners.
- Install insulation with no significant voids or edge gaps.
- All foundation insulation must be covered with an ignition barrier. Gypsum board (3/8 inch) or ¼ inch hardboard are a couple of materials that meet this requirement. Insulation may be left exposed without an ignition barrier if specifically approved for such installation.
- 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 31155, “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 2151-3).



**Figure 2151-1: Foil-faced rigid foam board on foundation walls, vents sealed and continuous and sealed**



**Figure 2151-2: Two-part spray foam applied to foundation wall with ground cover**



**Figure 2151-3: Combustion air intake from crawl space; floor above crawl space is thermal boundary**

<sup>41</sup> See SWS 2.0403.1d, “Overlap Seams”

- 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”).

## 2152 Crawl Space Floor Insulation<sup>42</sup>

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 2122, “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 31113, “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

### *Batt insulation*<sup>43</sup>

Batt insulation used to insulate floor joist cavity should be the maximum R-value structurally allowable (Figure 2152-1) by the floor framing. 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 2152-2).



**Figure 2152-1: Insulation should fill floor cavity**



**Figure 2152-2: Twine used to hold batt insulation in floor above crawl space**

<sup>42</sup> See SWS 4.1301, “Accessible Floors”

<sup>43</sup> See SWS 4.1301.1, “Standard Floor System”

- 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 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 2152-3).
  - 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 rim joist. 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 2154, "Ground Moisture Barrier."



**Figure 2152-3: Compressed insulation due to insulation support**

### *Spray foam*

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.

Spray foam insulation must be covered with an ignition barrier. An intumescent coating<sup>44</sup> approved by the spray foam manufacturer may be used. Insulation may be left exposed without an ignition barrier if specifically approved for such installation.

### *Dense Pack with Rigid Barrier*<sup>45</sup>

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<sup>3</sup> and fiberglass shall be installed at a minimum density of 2.25#/ft<sup>3</sup>. All holes made for insulation installation and other penetrations shall be sealed.

Install a ground air-moisture barrier per section 2154, "Ground Moisture Barrier."

<sup>44</sup> An intumescent coating is a type of paint that bubbles up when exposed to flame or heat. The bubbled-up paint acts as a flame-resistant barrier to delay ignition. Most manufacturers of spray foam sell intumescent coatings that have been approved for use with their brands of foam insulation.

<sup>45</sup> See SWS 4.1301., "Dense Pack Floor System with Rigid Barrier"

### *Loose Fill with Netting*<sup>46</sup>

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 2154, "Ground Moisture Barrier."

### 2153 Crawl Space Access

Crawl space access hatches from conditioned 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 2153-1). Access covers must be easily removable for entrance into the crawl space (Figure 2153-2).

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, etc) shall be installed to provide substantially airtight closure.<sup>47</sup>

### 2154 Ground Moisture Barrier<sup>48</sup>

**Ground moisture barriers are required regardless of the crawl space thermal boundary location**, regardless if the crawl space will be insulated, with the following exceptions.

- The crawl space is not accessible,
- The crawl space is supported on piers, and
- Mobile homes.

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

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.

Ground moisture barriers should be minimum 6 mil polyethylene plastic (Figure 2154-1). 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.



**Figure 2153-1: Peel & stick weatherstripping is not permitted**



**Figure 2153-2: Crawl space access hatch; weatherstripped and easily removable**



**Figure 2154-1: Minimum 6 mil ground cover; sealed to foundation wall with 2-part foam**

<sup>46</sup> See SWS 4.1301.2, "Standard Floor System – Loose Fill with Netting"

<sup>47</sup> See SWS 2.0701.1b, "Crawl Spaces – Providing Access". A variance has been provided where locks to not have to be installed on exterior crawl space access hatches.

<sup>48</sup> See SWS 2.0403.2, "Closed Crawl Spaces – Ground Moisture Barriers"



- 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 will 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 #8086 builders' tape or equivalent.
- Seal the ground moisture barrier to concrete footings with acoustical sealant or another effective adhesive.
- 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.
- Air conditioner condensate lines draining into to crawl space must drain to the outside or below the ground moisture barrier. The opening around the condensate line and ground moisture barrier must be well sealed to prevent condensate from collecting on top of the ground moisture barrier (Figure 2154-2).



**Figure 2154-2: Condensate line draining on top of ground moisture barrier**

## 2155 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 31113, "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.



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<sup>49</sup>

Basement wall insulation should be a minimum R10. Basement foundation insulation must be covered with a material that has an ASTM flame spread rating of 25 or less (such as ½ inch gypsum board).

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



**Figure 2161-1: Rigid foam board basement wall insulation**

### 2161 Rigid Foam Board Insulation

- Rigid foam board insulation may be installed directly to the basement wall with mechanical fasteners and insulation compatible adhesives (Figure 2161-1).
- 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.
- Foil-faced rigid insulation may be exposed as the foil may have an ASTM flame spread rating of 25 – check with insulation manufacturer.
- Unfaced extruded or expanded polystyrene must be covered with a material that has an ASTM rating of 25 or less. Vertical edges of the insulation may be routed to accept a 1 inch x 2 inch or 1 inch x 3 inch furring strip. The furring strips may be used to help secure the insulation to the basement wall with power driven masonry nails. An acceptable flame spread material such as gypsum board or FSK<sup>50</sup> paper may be attached to the furring strips.
- 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.

### 2162 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 2162-1). The insulation is installed horizontally along the wall and attached to furring strips. Ensure that the vinyl facing meets the flame spread rating.

<sup>49</sup> See SWS 4.1402.2, “Basement Wall Insulation – No Ground Water Leakage”

<sup>50</sup> A vapor retarder laminate of foil/ scrim (reinforcement) kraft construction - also known as FSK paper.

- 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.<sup>51</sup>



**Figure 2162-1: Vinyl faced fiberglass insulation**

## 217 Rim Joist Insulation

Penetrations in rim joist must be sealed before insulating. Two-part spray foam is recommended for air sealing and insulating the rim joist. 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 2171-1: 2-part spray foam on rim joist**

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 rim joist.

### 2171 Two-Part Spray Foam<sup>52</sup>

Provide minimum 1 inch thick spray foam (R7) when air sealing. A minimum 2" thick spray foam (R14) shall be used when insulating the rim joist.



**Figure 217-1: Batt insulation is not permitted to be used for rim insulation**

Foam shall make a good seal between the subfloor and rim joist and between the rim joist and sill plate. Spray foam shall also extend down past the sill plate to foundation wall (Figure 2171-1). Faced batt insulation may be installed over the two-part spray foam to increase the R-value of the rim joist.

The International Residential Code (2012 IRC) allows the exposed use of spray foam at rim joists (i.e., without a 15-minute ignition barrier such as drywall), as long as the thickness is less than 3-1/4" (see R316.5.11). However, foam must be covered with an approved thermal barrier if exposed to an occupiable space.<sup>53</sup>

<sup>51</sup> See SWS 4.1402.2c, "Vapor Permeability".

<sup>52</sup> See SWS 4.1401.1, "Band/Rim Joists – Spray Polyurethane Foam Installation".

<sup>53</sup> See SWS 4.1401.1c, "Fire Protection".

## 2172 Rigid Foam Insulation<sup>54</sup>

Provide a minimum R10 rigid insulation. Insulation board should be placed firmly against rim joist. 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 2172-1). Both extruded polystyrene and foil-faced polyisocyanurate may be used.



**Figure 2172-1: Rigid foam board sealed in place with 2-part spray foam**

## 218 Windows<sup>55</sup>

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.**

### 2181 Air Sealing

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

#### 21811 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.

#### 21812 Weatherstripping

- Large gaps between sash and sill and sash and stops may be weatherstripped. Meeting rails may also be weatherstripped or planed.
- Weatherstripping is to be secured by nails or staples, form a permanent airtight seal and not obstruct the operation of the sash.

### 2182 Exterior Storm Windows

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.

<sup>54</sup> See SWS 4.1401.2, "Band/Rim Joists – Insulation other than Spray Polyurethane Foam"

<sup>55</sup> See SWS 3.1201.1, "Double Hung Wood Windows" and 3.1201.2, "Single Unit Window and Fixed Frame with Wood Sash"

- 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.

### 2183 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.

### 21831 Glass Replacement

- 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<sup>2</sup> when the bottom edge is less than 18 inches above the floor.

### 21832 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.

### 21833 Stops

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.
- 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.

#### 21834 Sills

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.

#### 21835 Sash Locks

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.

#### 21836 Sash Replacement

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.

- 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.

#### 2184 Window Replacement<sup>56</sup>

Replacement windows shall be ENERGY STAR rated with a U-value no higher than 0.27 and a Solar Heat Gain Coefficient (SHGC) no lower than 0.32.

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 0.27, a SHGC no lower than 0.42 and be ENERGY STAR rated.

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 2184-1.

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<sup>56</sup> See SWS 3.1203.1, “Replacement Window in Existing Window Frame”



At least one NFRC label must be removed by the contractor and submitted with the contractor's invoice upon completion of the home for verification. The remaining NFRC labels shall be left on the window for removal by the final inspector.

**Windows may only be replaced if SIR is greater than or equal to 1.0 or has been approved as an air sealing measure.**



Figure 2184-1: NFRC label

## 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. **Doors may only be replaced if SIR is greater than or equal to 1.0 or has been approved as an air sealing measure.**

### 2191 Air Sealing

The following air sealing measures are done when identified with the blower door (Figure 2191-1).

#### 21911 Weatherstripping

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.

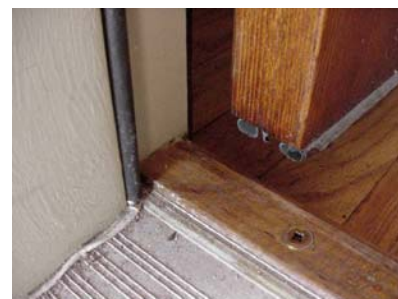


Figure 2191-1: Door weatherstripping, threshold and sweep

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  $\frac{1}{4}$  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.

#### 21912 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.

#### 21913 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<sup>57</sup>.

#### 2192 Door Replacement

**Doors may only be replaced if SIR is greater than or equal to 1.0 or has been approved as an air sealing measure.**

**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 0.30.

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.

- Replacement doors should not have glass panes. If homeowner is persistent, install smallest glass pane as possible or a door viewer. Maximum glazing area shall be “half moon” (Figure 2192–1) or no more than two square feet (approximately two lites).
- All replacement doors must have a solid wood core or an exterior-grade foam core.
- 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).



**Figure 2192-1: Half moon door**

<sup>57</sup> See SWS 3.1201.3, “Exterior Doors”, and 3.1201.8, “Repair, Maintenance and Weatherstripping of Doors”

The client is to receive all keys - minimum two keys per lockset. If possible, multiple locks should be keyed alike.

#### 2193 Pre-Hung Replacement Doors

If a pre-hung door is needed, either a wood or steel foam filled door may be used. Replacement doors must meet the 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

#### 2194 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.

#### 21941 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 doorstep.
- Strike plate is to be mortised into the jamb.

#### 21942 Stops

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

- Wood used for door stop is to be manufactured as doorstep.
- 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.

#### 21943 Locksets/Strikeplates

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.

## 2195 Storm Doors

Storm door installation or replacement is not allowed.

## 220 Baseload<sup>58</sup>

### 2201 Light Emitting Diodes (LEDs)

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 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

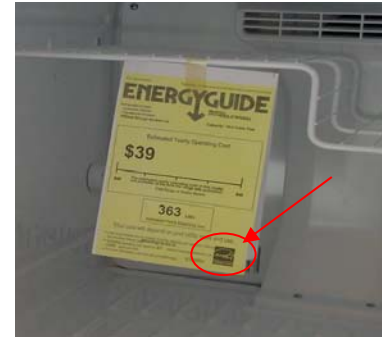
<sup>58</sup> See SWS 7.8003.1, "Lighting Upgrade"

- LED lamps should be listed as “soft white” (or have a Kelvin temperature of 2700° to 3000°K) 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.**

## 2202 Replacement Refrigerators and Freezers<sup>59</sup>

Replacement refrigerators and freezers shall be ENERGY STAR rated (Figure 2202-1). 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.

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.



**Figure 2202-1: Replacement refrigerators and freezers must be ENERGY STAR rated**

Replacement refrigerators should have the following features:

- Freezer on top
- Auto defrost
- 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:<sup>60</sup>

- 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,

<sup>59</sup> See SWS 7.8001.1, “Refrigerator and Freezer Replacement”

<sup>60</sup> From “Incorporating Refrigerator Replacement into the Weatherization Assistance Program”, USDOE, 2001



- 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.

#### 22021 Disposal

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.

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.

#### 2203 Low Flow Showerheads<sup>61</sup>

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).

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.



#### 2204 Aerators

Aerators shall have a maximum flow rate of 1.5 gpm and shall have the *WaterSense* label (Figure 2203-1).

**Figure 2203-1:**  
***WaterSense* label**

#### 2205 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.

<sup>61</sup> See SWS 7.810.1, "Shower Head and Faucet Aerator"

## 300 – Mechanical Standards

### 311 Combustion Efficiency and Venting

This combustion efficiency and venting 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.

#### 3111 Natural Gas and Propane

##### 31111 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.

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 31111-1).
2. Clean, vacuum and adjust burners (Figure 31111-2).
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.
6. Check venting system for proper size, pitch and connection by referencing NFPA 54 (Figure 31111-3).<sup>1</sup>
7. Check venting system for obstructions, blockages or signs of condensation (Figure 31111-4).
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 31111-1: Evidence of flame roll-out**



**Figure 31111-2: Clean burners with stiff brush**



**Figure 31111-3: Ensure that vent is properly connected**

<sup>1</sup> See SWS 2.0205, "Gas and Oil-Fired Equipment"

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.**

2. *Spillage* (see section 3122)<sup>2</sup> - the spillage test only applies to natural draft appliances;  
*Natural Draft 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.

*Natural Draft Furnaces - Warm Vent* (when furnace thermostat is on heat)

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

*Natural Draft Furnaces - Cold Vent* (when furnace thermostat is not on heat)

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

If the natural draft appliance is common vented (multiple combustion appliances sharing chimney and/or venting system) to an induced draft appliance the 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 3123)<sup>3</sup>; 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”).



**Figure 31111-4: Check vent for condensation problems**

<sup>2</sup> ANSI/BPI-1200-S-2017, “Standard Practice for Basic Analysis of Buildings”, sections 7.9.2 and 7.9.3

<sup>3</sup> See SWS 2.0201.1g, “CAZ Testing – CO in Test Appliance Vent”

## Acceptable Combustion Test Analysis Measurements

Table 300-1

Heating Unit Type	Oxygen (O <sub>2</sub> )	Carbon Dioxide (CO <sub>2</sub> )	Net Stack Temp.	Smoke Test
<b>Gas</b>				
Atmospheric	4 - 9%	Natural 9.6 - 6.8% LPG 11.2 - 7.8%	300-600° F	NA
Fan-assisted	4 - 9%	Natural 9.6 - 6.8% LPG 11.2 - 7.8%	300-480° F	NA
Condensing	See man. Info. (4% - 9%)	See man. Info.	See man. Info.	NA
Standard Power Burner	4 - 9%	Natural 9.6 - 6.8% LPG 11.2 - 7.8%	300-550° F	NA
<b>Oil (No. 1 &amp; 2)</b>				
Oil gun burner	4 - 9%	12.5 - 8.8%	325-600° F	2 or less
Flame Retention Burner	4 - 7%	12.5 - 10.3%	325-600° F	2 or less

## 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	654	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 stop watch, measure the number of seconds for either the ½ ft³ or the 1 ft³ 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/ft³.

### 31112 Leak-testing Gas Piping<sup>4</sup>

Natural gas and propane piping systems may have leaks at their joints and valves. Assessors, Mechanical Weatherization Workers and Final Inspectors must perform a gas leakage test on all

<sup>4</sup> See SWS 2.0201.1b, "CAZ Testing – Fuel Leak detection"

gas supply lines, couplings, joints and connections. Find gas leaks with an electronic combustible-gas detector, often called a gas sniffer. Move the gas sniffer along the entire gas line at a rate of 1" per second with the tip above the line for natural gas and below for LP gas. Move the gas sniffer wand in a 360-degree circle completely around each joint at a rate of 1" per second.

- Check all valves and joints with the gas sniffer.
- Locate leaks using a non-corrosive bubbling liquid designed for finding gas leaks.

All gas leaks and damaged gas lines must be repaired.

### 31113 Combustion Air<sup>5</sup>

A combustion appliance located in a confined space, surrounded by materials that are tight or marginal air barriers may need an outdoor source of combustion air. For every 1,000 Btu input, there should be 2 square inches (in<sup>2</sup>) of free ventilation area. For example, the furnace and water heater are in a furnace closet. The furnace has an input rating of 100,000 Btus. The water heater has an input rating of 40,000 Btus. There should be 280 in<sup>2</sup> of free ventilation area to the furnace room  $[(100,000 + 40,000)/1,000 = 140 \times 2 \text{ in}^2 = 280 \text{ in}^2]$ .

### 3112 Fuel Oil Systems<sup>6</sup>

These procedures pertain to oil-fired furnaces, boilers and water heaters.

#### 31121 Oil-burner Inspection and Testing

All oil burners shall be inspected and tested. Use visual inspection and combustion testing to evaluate oil burner operation. Refer to Table 300-1 for oil heating system guidelines.

A smoke test should precede combustion testing. Smoke spot reading will be in accordance with manufacturer specifications. In the absence of manufacturer's specifications, smoke number shall not exceed 2. Efforts to reduce smoke should precede combustion testing to protect the combustion testing equipment from damage.

The following steps are a minimum standard for oil-burner evaluation.

- Inspect burner and appliance for signs of soot, overheating, fire hazards, or wiring problems.
- Inspect fuel line for leaks.
- Inspect heat exchanger and combustion chamber for cracks, corrosion, or dirt.
- Check to see if flame ignition is instantaneous or delayed. Flame ignition should be instantaneous.
- Sample undiluted flue gases with a smoke tester, following the smoke-tester instructions. Compare the smoke smudge left by the gases on the filter paper with an approved scale to determine smoke number.
- Test for CO with house set-up for worst-case depressurization identified in section 3121, "Worst Case Depressurization" with flue gas analyzer in undiluted flue gases upstream

<sup>5</sup> See SWS 2.0205.1a, "Gas and Oil-Fired Equipment – Combustion Air"

<sup>6</sup> See SWS 5.3003.2, "Combustion Analysis of Oil-Fired Appliances"



from the barometric draft control. A CO reading of 400 ppm<sup>7</sup> air-free is considered the maximum acceptable level.

- Determine steady-state efficiency from O<sub>2</sub> percentage and flue gas temperature in undiluted flue gases upstream from the barometric draft control.
- Check and clean thermostat.
- Technicians may need to perform other tests to diagnose efficiency, safety, or operational problems—oil-pump pressure or transformer voltage, for example.

### 31122 Oil burner Maintenance and Adjustment

Perform some or all the following maintenance tasks as needed to optimize safety and efficiency.

- Verify correct flame-sensor operation.
- Clean or replace burner nozzle.
- Clean the burner's blower wheel.
- Clean or replace oil filter(s).
- Clean or replace air filter.
- Remove soot and sludge from combustion chamber.
- Remove soot from heat exchange surfaces.
- Clean the oil pump screen.
- Clean dust, dirt and grease from the entire burner assembly.
- Set oil pump to correct pressure.
- Adjust air shutter for minimum smoke.
- Adjust barometric damper to about 0.03-to-0.06 inches W.C. draft downstream from the barometric draft control.
- Adjust gap between electrodes to manufacturer's specifications.
- Repair the ceramic electrodes, or replace it if necessary.
- Replace or adjust barometric damper.
- Measure CO in undiluted flue gases upstream from the barometric draft control. A CO reading of 400 ppm air-free is considered the maximum acceptable level.

After these maintenance procedures, the technician shall perform the diagnostic tests described above to evaluate improvement made by the maintenance procedures and to determine if fine-tuning is required.

### 3113 Electric Heating Systems<sup>8</sup>

The following measures shall be done on all electric furnaces.

- 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.

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<sup>7</sup> ANSI/BPI-1200-S-2017, "Standard Practice for Basic Analysis of Buildings", Table 1

<sup>8</sup> See SWS 5.3003.16, "Evaluating Electrical Service"

### 3114 Wood Burner Safety (Figure 3114-1)

- 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 and seal leaks with a high-temperature sealant designed for use with metal or masonry.
- Inspect chimney and vent connector for creosote build-up and clean chimney if significant creosote build-up exists.
- Inspect the house for soot on seldom-cleaned horizontal surfaces. If soot is present, replace the gasket on the wood-stove door, seal other air leaks and take steps to improve draft, as necessary to reduce indoor smoke emissions.
- Inspect and clean damper and/or combustion air intake if present (Figure 3114-2).
- Check and replace fire door gaskets if applicable.
- Check catalytic converter for repair or replacement if applicable.
- Conduct Worst Case Depressurization test to check for potential backdrafting (see section 3121, “Worst Case Depressurization”).



**Figure 3114-1: Wood burner**



**Figure 3114-2: 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.

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.<sup>9</sup>

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



**Figure 312-1: Personal CO monitor**

<sup>9</sup> ANSI/BPI-1200-S-2017, “Standard Practice for Basic Analysis of Buildings”, section 7.3.3

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



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

There are three parts to this test.<sup>10</sup>

1. *Determining worst case depressurization condition* (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.**
2. *Spillage* (see section 3122)<sup>11</sup> - the spillage test only applies to natural draft appliances;  
*Natural Draft 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.  
*Natural Draft Furnaces - Warm Vent* (when furnace thermostat is on heat)  
Spillage must cease (furnace begins drafting) within two minutes. If furnace begins drafting within two minutes, the furnace passes the test.  
*Natural Draft Furnaces - Cold Vent* (when furnace thermostat is not on heat)  
Spillage must cease (furnace begins drafting) within five minutes. If furnace begins drafting within five minutes, the furnace passes the test.

If the natural draft appliance is common vented (multiple combustion appliances sharing chimney and/or venting system) to an induced draft appliance the 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 3123)<sup>12</sup>; 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, fireplaces and vented space heaters.

Potential solutions for Combustion Safety Testing failures are presented in section 3125.

<sup>10</sup> See SWS 2.0201.1e, "CAZ Testing"

<sup>11</sup> ANSI/BPI-1200-S-2017, "Standard Practice for Basic Analysis of Buildings", sections 7.9.2 and 7.9.3

<sup>12</sup> See SWS 2.0201.3b, "CAZ Testing – CO in Test Appliance Vent"

### 3121 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 combustion appliances are sealed combustion (direct vent) with no woodstoves or fireplaces.
2. If the house or mobile home is all-electric with no combustion appliances, woodstoves or fireplaces.
3. 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.
4. 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.

#### 31211 Manometer Set-Up<sup>13</sup>

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 31211-1).
- 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.

Tap may be left open if measurements are taken in the CAZ

To outside



**Figure 31211-1**  
**Manometer set-up**  
**for WCD test**

Measurements made with the house in the worst case depressurization condition will likely be quite small. Trying to take these readings on a windy day can be very 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.

#### 31212 House Set-Up

House should 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.

<sup>13</sup> See SWS 2.0201.d, “CAZ Testing – Base Pressure Test”

- 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.

### 31213 Determining Worst Case Depressurization Condition<sup>14</sup>

1. Set the adjusted baseline with house set-up as described above<sup>15</sup>. 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<sup>16</sup>. 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 handler on for P3 measurement.
  - If the pressure becomes more positive, turn off air handler for P3 measurement.
4. Open CAZ door.
  - If the pressure becomes more negative, leave CAZ door open.
  - If the pressure becomes more positive, close CAZ door.
 Record the pressure difference (**P3**).
5. Compare the three readings. The reading with the highest negative number is the worst case. The house shall remain in this configurations for the spillage test and for measuring CO. Note that this CAZ procedure must be repeated for each CAZ in the home.

### 3122 Spillage Test<sup>17</sup> (natural draft appliances only)

Fire the appliance with the smallest Btu capacity first and test for spillage at the draft diverter with a smoke pencil.

#### *Natural Draft 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 3122-1).

#### *Natural Draft Furnaces - Warm Vent (when furnace thermostat is on heat) –*



**Figure 3122-1: Appliance passes spillage test**

<sup>14</sup> A WCD “cheat sheet” for house set-up, manometer set-up and recording pressures is attached at the end of this section.

<sup>16</sup> 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.

<sup>17</sup> ANSI/BPI-1200-S-2017, “Standard Practice for Basic Analysis of Buildings”, sections 7.9.2 and 7.9.3



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

*Natural Draft Furnaces - Cold Vent* (when furnace thermostat is not on heat) –

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 natural draft appliance in a common vented system. The induced draft appliance must be checked for spillage at the diverter of the natural draft appliance. The appliances must be checked for spillage in order of appliance input rating. Spillage must stop within 2 minutes.

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 3122-2), 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 3124, “Solutions to Combustion Safety Testing Failures”.



**Figure 3122-2: Appliance fails spillage test**

Any appliance that fails the spillage test may not be left in that condition<sup>18</sup>. 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 3123, “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 3124, “Solutions to Combustion Safety Testing Failures”, for potential actions for appliances that fail the spillage test.

### **3123 Carbon Monoxide (CO) Testing**

- 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.

<sup>18</sup> See SWS 2.0201.3a, “Spillage Test”

## CO Threshold Limits for Combustion Appliances<sup>19</sup>

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”).

### *Natural Draft Appliances*

- Readings must be taken just before the emissions are diluted by room air at the draft diverter (Figure 3123-1). 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.

### *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).
- See section 3132, “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.



**Figure 3123-1: CO reading taken for water before dilution air**

## **3124 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.

<sup>19</sup> ANSI/BPI-1200-S-2017, “Standard Practice for Basic Analysis of Buildings”, Table 1

- 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.
- c. Properly seal return duct leakage in the CAZ (Figure 3124-1) 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 3124-2).
- 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 3124-3).



**Figure 3124-1: Repair duct system**



**Figure 3124-2:  
Combustion air intake**

### **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.

#### **3131 Natural Draft Appliances**

The following inspection procedures and maintenance practices are required for all natural draft 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.



**Figure 3124-3: Transfer grille**

- 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.

### 3132 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 31111, “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 300°F and 480°F.

### 3133 Direct Vent Sealed Combustion Appliances (+ 90% condensing – Figure 3133-1)

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 31111, “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.
- 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%).



**Figure 3133-1: Direct vent sealed combustion furnace**

### 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  $\frac{1}{4}$  inch per foot.

#### 3141 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 31: Standard for the Installation of Oil-Burning Equipment
- NFPA 211: Standard for Chimneys, Fireplaces, Vents, and Solid-Fuel-Burning Appliances 1996 Edition

#### 3142 Vent Connectors

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

- Galvanized-steel pipe ( $\geq 0.018$  in. thick),
- 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.

#### 3143 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.

#### 3144 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.

#### 3151 Furnace Repair

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 3151-1: Furnace heat exchanger**

#### 3152 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.
- 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.



**Figure 3152-1: Pull blower fan**

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. Filter changing procedure shall be explained to client<sup>20</sup>.
- Pull the blower fan and clean. Vacuum the compartment (Figure 3152-1).
- 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.

### 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°
<b>Heat rise = Supply temperature – Return temperature</b>		
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°
<b>Fan-off Temperature</b>		
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°
<b>Fan-on Temperature</b>		

### 3153 Ducts

#### 31531 Duct Leakage Sites

The following joints should be inspected and sealed (Figure 31531-1). Ducts located outside the thermal boundary should be sealed.

- Seal holes in the air handler and joints between the air handler and the supply and return ducts.
- Filter slot must have system that will cover the opening but is easy for the occupant to open and close (Figure 31531-2).



**Figure 31531-1: Inspect the ducts!**

<sup>20</sup> See SWS 5.3003.7f, "Occupant Education – Routine Maintenance"

- Seal leaky joints between main supply and return ducts and their branches (Figure 31531-3).
- Seal leaky joints between building materials composing cavity return ducts, like panned floor cavities and furnace return platforms. Even better: replace cavity return ducts with new metal return ducts.
- Seal leaky joints between supply and return registers in the floor, wall and ceiling to which they are attached.
- Secure metal duct joints with screws, seal them with mastic, and support joints with duct hangers.
- 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 31531-4).
- Patch or replace metal ducts that have rusted through and ducts with holes cut in them (Figure 31531-5).
- Seal penetrations made by wires or pipes traveling through ducts. Even better: move the pipes and wires and patch the holes.
- Seal return air grilles in basement (Figure 31531-6). Re-check temperature rise to assure that it is within the operating limits of the furnace.



**Figure 31531-2: Metal filter cap**



**Figure 31531-3: Seal leaks and connections in supply and return ducts**



**Figure 31531-4: Permanently seal registers in unconditioned spaces**



**Figure 31531-5: Seal holes in ducts**

### 31532 Duct Sealing Materials<sup>21</sup>

**Duct mastic is the required duct sealing material because of its superior durability and adhesion. Tapes cannot be used for duct sealing in the Illinois Weatherization Program (Figure 31532-1).**

Apply at least 1/16-inch thick mastic and use reinforcing fiberglass mesh tape for all joints wider than 1/16 inch or joints that may experience some movement (Figure 31532-2). Duct sealing mastics should be UL181A or UL181B labeled.

Tape is not to be used as it cannot be expected to hold a joint together nor expected to resist the force of compacted insulation or joint movement (Figure 31532-3). Joints should rely on mechanical fasteners to prevent joint movement or separation and mastic for sealing.

<sup>21</sup> See SWS 3.1602.1, “Air Sealing Duct System”



### 31533 Duct Insulation

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-skrim-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. Even a small void in the insulation can dampen a large section of insulation through condensation.
- Insulation should be fastened by mechanical means such as stuck-ups, twine, or plastic straps. Tape can be effective for covering joints in the insulation to prevent air convection, but tape will usually fail if expected to resist the forces of compressed insulation or the insulation's weight.

### 31534 Duct System Airflow<sup>22</sup>

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.

### 3154 Central Air Conditioners (Figure 3154-1)

#### 31541 Cooling Clean & Tune

- 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.<sup>23</sup>
- 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.<sup>24</sup>

<sup>22</sup> See SWS 5.3003.3a, "Evaluating Air Flow". Note that existing testing protocols used in the IHWAP meet the objective of the specification. Use of additional testing equipment as specified in the SWS is not required.

<sup>23</sup> See SWS 5.3003.3, "Evaluating Air Flow"

<sup>24</sup> See SWS 5.3003.5, "Refrigerant Line Inspection"



**Figure 31531-6: Return air grilles should be sealed**



**Figure 31532-1: Tape is not to be used for sealing ducts in the Illinois WX Program**



**Figure 31532-2: Duct mastic used to seal duct joints**



**Figure 31532-3: Tape is not expected to hold a joint together**

- Clean the outdoor condenser coil.
- 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.
- Oil motors and check belts for tightness and wear.
- Check the accuracy of the thermostat.



**Figure 3154-1: Central AC**

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.

### 31542 Central Air Conditioner Replacement

Replacement central air conditioners must be ENERGY STAR rated with a minimal SEER<sup>25</sup> of 15 or the current ENERGY STAR minimum SEER requirement. Mobile home air conditioners shall have a minimum SEER rating of 14.

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.<sup>26</sup>

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

<sup>25</sup> Seasonal Energy Efficient Ratio

<sup>26</sup> See SWS 5.3003.7, "Occupant Education"



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<sup>27</sup> 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 31541, “Cooling Clean and Tune”.

### 3155 Heat Pumps

- Heat pumps shall be ENERGY STAR rated. For split systems, minimum HSPF shall be 8.5 with a minimum SEER of 15 (12.5 EER) or the current ENERGY STAR minimum SEER 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.
- 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.

### 3156 Room Air Conditioner

Replacement room air conditioners (Figure 3156-1) 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 3156-1: Room air conditioner**

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<sup>27</sup> Air Changes per Hour

Window units shall be sized appropriately. The guide<sup>28</sup> 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

The following adjustments may be made<sup>29</sup>.

- 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.

### 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.

#### 3161 Hot Water Systems (Figure 3161-1)

- 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.



Figure 3161-1: Warm water boiler

<sup>28</sup> From energystar.gov

<sup>29</sup> From energystar.gov

- 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.

### 3162 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.

### 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 ANSI Z21.11.2. 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.

### 318 Advanced and Automatic Setback Thermostats

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

- When replacing existing thermostats, identify and dispose of any mercury containing thermostats in accordance with Environmental Protection Agency (EPA) guidance.<sup>30</sup>
- 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.
- A heating/cooling thermostat must be used if the home is centrally air conditioned.



**Figure 318-1: Advanced thermostat**



**Figure 318-2: Automatic setback thermostat**

<sup>30</sup> See SWS 2.0103.2b, “Safe Work Practices”

- 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<sup>31</sup>.

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. Properly 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 for inclusion as a permanent part of the client file.<sup>32</sup>

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.

Replacement furnaces equipped with electrically commutated motors (ECM) may be installed. However, external static pressure should be less than 0.5" w.c. (125 Pa) before installing a furnace with an ECM air handler. The replacement furnace must still have a minimum AFUE of 95%.

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

<sup>31</sup> See SWS 5.3003.7, "Occupant Education"

<sup>32</sup> See SWS 5.3001.1, "Load Calculation and Equipment"

## Replacement System Minimum Efficiencies

Table 300-6

Natural Gas/LP Furnaces	95%, Direct vent sealed combustion
Oil Furnaces	83%
Warm Water Gas Boilers	90%
Steam Boilers	80%
Oil Boilers	80%
Central Air Conditioners	Current ENERGY STAR minimum <sup>33</sup>
Air Source Heat Pumps & Mini-Split Systems	Current ENERGY STAR minimum <sup>34</sup>

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.

### 3191 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.
- 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 3121, “Worst Case Depressurization”).
- 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.
- Properly sized and installed flexible gas appliance connectors are permitted on furnace, boiler and water heater installations.
- Repair or replace unsafe power supply to appliance.
- Install a properly sized and dedicated circuit to the heating appliance if one is necessary.

<sup>33</sup> As of April 2018, minimum SEER is 15.0

<sup>34</sup> As of April 2018, minimum HSPF of 8.5, minimum SEER of 15 (or 12.5 EER)



### 3192 Oil Fired Heating Systems

- Oil furnaces must have a minimum AFUE of 83%. Oil boilers must have a minimum AFUE of 80%.
- Examine existing chimney and vent connector for suitability as venting for new appliance. The vent connector may need to be re-sized and the chimney may need to be re-lined. Venting should be in compliance with NFPA 31, chapters 1 through 11.
- Check clearances of heating unit and its vent connector to nearby combustibles, by referring to NFPA 31, tables 4-4.1.1, 4-4.1.2 and 5-5.1.
- Test oil pressure to verify compliance with manufacturer's specifications.
- Test transformer voltage to verify compliance with manufacturer's specifications.
- Adjust oxygen, flue-gas temperature and smoke number to within manufacturer's specifications.
- Inspect oil tank and remove deposits at bottom of tank as part of new installation.
- Install new fuel filter and purge fuel lines as part of new installation.
- Bring tank and oil lines into compliance with NFPA 31, Chapters 2 and 3 and appropriate state regulations.
- Repair or replace an unsafe power supply to appliance.
- Install a properly sized and dedicated circuit to the heating appliance if one is necessary.

### 3193 Furnace Installation

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 should be sized to the home's approximate heating load, accounting for weatherization heat loss reductions.
- If funds are available, return ducts and/or supply ducts must be included with furnace replacement to improve air distribution 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<sup>35</sup>.
- 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.

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<sup>35</sup> See SWS 5.3001.5, "Ductwork and Termination Design – Low Rise"

- 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.<sup>36</sup> 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.
- 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.

#### 3194 Boiler Installation

- Warm water boilers shall have a minimum seasonal efficiency of 90%. A properly configured outdoor reset control is recommended with new boiler installations.
- Steam boilers shall have a minimum seasonal efficiency of 80%.
- All boiler work must be in compliance with:
  - The Uniform Mechanical Code
  - National Fire Prevention Association (NFPA)
  - Local Codes (where existing)
  - Boiler Manufacturer's Specifications
- Boiler should be sized to the home's heating load, accounting for weatherization heat loss reductions.
- 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.
- A pressure relief valve must be installed with the new boiler and discharge pipe installed to within 6 inches of the floor.
- Extend new piping and radiators to conditioned areas like additions and finished basements, currently heated by space heaters.

#### 3195 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

<sup>36</sup> See SWS 5.3001.1c, "Air Filtration"

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.

### 3196 Wood Heating Installation<sup>37</sup>

- 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.<sup>38</sup>

## 320 Water Heater Retrofits

### 3201 Tank Insulation

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.

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 6 inches above the floor and be made of rigid metallic material. There shall be no threads on the end of the discharge pipe<sup>39</sup>.

Water heaters shall be insulated to a minimum total R-value (tank plus new insulation) of R24<sup>40</sup>. Insulation must be mineral fiber manufactured as a water heater blanket with vinyl or foil facing. The insulation must conform to ASTM C592-80 and ASTM 892-79 with a flame spread rating no higher than 25.

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

Insulation shall be secured to the water heater utilizing:

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<sup>37</sup> See SWS 2.0201.2f, “Solid Fuel Burning Appliances”

<sup>38</sup> See SWS 5.3003.7, “Occupant Education”

<sup>39</sup> See SWS 7.8103.1, “Storage Type Appliance”. A variance has been provided that water heater expansion tanks do not need to be installed.

<sup>40</sup> See SWS 7.8103.1c, “Storage Type Appliance”

- 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.

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*

- 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*

- Set both upper and lower thermostat to keep water at 125°F before insulating water heater.
- 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.

### 3202 Pipe Insulation

- Insulate first 6 feet of both hot- and cold-water pipes.
- Cover elbows, unions and other fittings to same thickness as pipe.
- Keep pipe insulation at least 3 inches away from flue pipe.
- Interior diameter of pipe sleeve must match exterior diameter of pipe.

### 3203 Water Heater Replacement<sup>41</sup>

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 Uniform Mechanical Code, 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. All replacement water heaters must have a pressure relief valve and a discharge pipe extending within 6 inches of the floor.

<sup>41</sup> See SWS 7.8102.1, "Water Heater Selection"

Properly sized and installed flexible gas appliance connectors are permitted on water heater installations.

### 32031 Electric Water Heaters

Electric storage tank type water heaters must have a minimum Energy Factor (EF) of 0.92.

Electric heat pump water heaters must have an Uniform Energy factor (UEF) greater than or equal to 2.00 and must be ENERGY STAR rated.

### 32032 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<sub>x</sub> burners. Gas and propane tankless water heaters must have a minimum UEF of 0.87 and be ENERGY STAR rated.

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.

### 32033 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.

## 321 Gas Ovens<sup>42</sup>

### 3211 Inspection

- Inspect the 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°F.
- 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.

### 3212 Replacement

Gas ovens may be replaced as a Health & Safety measure if high CO readings are found and/or the oven is non-repairable. DOE funds may not be used for stove replacement. **Non-operable**

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<sup>42</sup> See SWS 2.0201.2d & 2e, “Gas Ovens” and “Gas Range Burners”.



**stoves shall not be replaced.** 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 replace 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 on each home where mechanical work was completed. This document must be signed and dated by the contractor who completes the work. The Contractor Checklist may be downloaded from *WeatherWorks*.

- 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 provided to 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.

# CONTRACTOR CHECKLIST -

rev. 06/12/2015

Job# \_\_\_\_\_ Date \_\_\_\_\_ Contractor name \_\_\_\_\_  
 Client Name \_\_\_\_\_ Address \_\_\_\_\_ City \_\_\_\_\_  
 Phone \_\_\_\_\_ Furnace/Boiler brand & model number \_\_\_\_\_ Serial # \_\_\_\_\_

(Circle all that apply)

Residential Furnace			Mobile Home			Boiler		
Natural Gas	Propane	Electric	Clean & Tune	Appliance Replacement				
<b>Furnace</b>								
Inspect vent system & vent connections	Yes	No	NA	<b>90+ Furnaces</b>				
Electric shutoff switch present	Yes	No	NA	Two pipe vent installed per PMI	Yes	No	NA	
Manual gas valve present & operational	Yes	No	NA	Vent termination per PMI	Yes	No	NA	
Sediment trap at unit location present	Yes	No	NA	If no, state reason _____				
Clean & inspect pilot, & burners	Yes	No	NA					
Replace thermocouple	Yes	No	NA	<b>Mobile Homes</b>				
Inspect wiring for cracks & overheating	Yes	No	NA	Listed mobile home furnace	Yes	No	NA	
Clean and inspect heat exchanger	Yes	No	NA	Flue Collar/Roof Jack installed	Yes	No	NA	
Combustion Blower cleaned	Yes	No	NA	Defective floor registers replaced	Yes	No	NA	
Clean main blower and secondary heat exchanger	Yes	No	NA	Floor Supply/Return ducts/boots sealed	Yes	No	NA	
Vision impaired thermostat installed?	Yes	No	NA	Approved Mobile Home vent pipe	Yes	No	NA	
Set back thermostat installed & programed	Yes	No	NA					
Thermostat calibrated & leveled	Yes	No	NA	<b>Electric Heat</b>				
Are all rooms receiving heat	Yes	No	NA	Condition of Elements & Links _____				
Is adequate return air present	Yes	No	NA	Voltage _____				
Air filter cover present	Yes	No	NA	Condition of wiring _____				
Gas leak test all gas appliance & supply lines	Yes	No	NA	Rated amp draw _____ Measured amp draw _____				
Unit installed on blocks?	Yes	No	NA	Temp Rise per Manufacturer's Specifications _____				
				Supply temp.(AVG) _____ Return Temp. _____ Temp. Rise _____				
<b>Testing</b>				<b>Appliances</b>				
Worst case conditions ____PA	Spillage test passed	Yes	No	NA	<b>Gas Stove</b>			
Draft Reading (see table) _____	CO Reading _____				<b>Gas Dryer</b>			
Condition of Flame _____				Shutoff w/ handle present and operational				
Rated Input _____ Btuh	Clocked Input _____ Btuh				Sediment trap present			
Gas pressure _____ iwc.				Uncoated brass flex connectors replaced				
Temp rise per PMI _____				Gas leak test conducted				
Supply air temp (T1) _____ (T2) _____ (T3) _____ AVG _____				Rigid vent present & connected				
Return air Temp _____ Temp Rise _____								
Blower on temp _____ Blower off temp _____								
				<b>Acceptable draft values</b>				
				Below 21F -5 PA (0.020" WC)				
				21F to 40F -4 PA (0.016" WC)				
				41F to 60F -3 PA (0.012" WC)				
				61F to 80F -2 PA (0.008" WC)				
				Above 80F -1 PA (0.004" WC)				

**BOILER**

Inspect vent system & vent connectors	Yes	No	NA
Gas shutoff valve present & operational	Yes	No	NA
Sediment trap present	Yes	No	NA
Electric shutoff switch present	Yes	No	NA
Clean & inspect burners and pilot	Yes	No	NA
Clean & inspect heat exchanger?	Yes	No	NA
Inspect wiring?	Yes	No	NA
Gas leak test all appliance & supply lines	Yes	No	NA
Repair water/steam leaks?	Yes	No	NA
Fill Valve operational?	Yes	No	NA
IID/Vent Damper installed?	Yes	No	NA
Pressure/Temp. Valve operational?	Yes	No	NA
Expansion tank drained?	Yes	No	NA
System bled?	Yes	No	NA
Low Water cutoff cleaned?	Yes	No	NA
Is Low Water cutoff operational?	Yes	No	NA
Is water sight glass visible & cleaned?	Yes	No	NA
Pigtail removed & cleaned (Steam)	Yes	No	NA

**Testing**

Gas Pressure _____ iwc. Flue Temp _____ Degrees			
Worst case conditions _____ Pa CO reading _____			
Flame condition _____ Spillage test passed	Yes	No	NA
Circulator on Temp. _____ Circulator off temp. _____			
Rated Input _____ BTU Clocked Input _____			
Heat Anticipator settings _____			
Replace Thermostat	Yes	No	NA
Outdoor Temp. Controls Checked?	Yes	No	NA

**CLIENT INFORMATION**

Guarantee form been left with the client	Yes	No
PMI been left with the Client	Yes	No
Furnace Filters been left with the client	Yes	No
Sizing Chart been Completed	Yes	No

**OIL HEAT**

Oil Nozzle replaced?	Yes	No	NA
Chimney cleaned?	Yes	No	NA
Change Oil Filter?	Yes	No	NA
Barometric damper operational?	Yes	No	NA
Class A vent installed?	Yes	No	NA
Draft over flame? _____			
Oil Nozzle size _____ Smoke Test reading _____			
Efficiency _____ CO Reading _____ ppm			
Draft reading _____			
Condition of chimney _____			
Condition of fuel lines _____			
Stack control drop out time _____			
Condition of Electrodes _____			

**WATER HEATER** GAS \_\_\_\_\_ Electric \_\_\_\_\_

Draft Reading _____ iwc			
Worst case conditions _____ PA Spillage test passed	Yes	No	NA
CO Reading _____ ppm			
Condition of venting _____ Condition of burner _____			
Electric disconnect installed	Yes	No	NA
Manual shutoff w/handle installed & operational	Yes	No	NA
Drip Pan Installed	Yes	No	NA
T/P valve discharge pipe installed	Yes	No	NA
T.P Valve Operational	Yes	No	NA
Sediment trap installed	Yes	No	NA
Gas leakage test conducted	Yes	No	NA
Flue liner installed?	Yes	No	NA
Burner Door /Panel in Place?	Yes	No	NA

I certify that I have inspected all existing, and newly installed gas lines and gas appliances for any gas leaks, and that all combustion appliances are working safely within the specified IHWAP parameters. I understand that all invoices must be itemized with Labor/Material costs and submitted with the Work Order and this document.

\_\_\_\_\_  
Technician Signature

\_\_\_\_\_  
Date

# Worse Case Depressurization (WCD)

## House Set-Up:

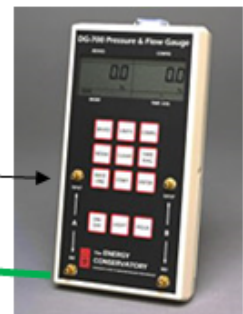
- ✓ close all exterior windows and doors
- ✓ close interior doors except for rooms with an exhaust fan and rooms with a ducted return
- ✓ close door to combustion appliance zone (CAZ)
- ✓ turn off all exhaust fans (including ASHRAE fan if present) and clothes dryer
- ✓ remove, clean and replace lint filter from dryer
- ✓ if dirty, remove filter from furnace; do not remove filter cap if present
- ✓ close supply air registers in CAZ
- ✓ close fireplace damper, if present
- ✓ set water heater to pilot or vacation; ensure other combustion appliances are off

## Manometer Set-Up:

- ✓ run hose from outside to reference tap on A channel
- ✓ leave tap open to CAZ

leave tap open to CAZ

to outside



## Baseline:

- ✓ set baseline on manometer

## Measurements:

- P1** Turn on clothes dryer and all exhaust fans<sup>1</sup> in house<sup>2</sup>: \_\_\_\_\_ Pa
- P2** Turn on furnace air handler: \_\_\_\_\_ Pa (leave clothes dryer & exhaust fans running)
- If the pressure becomes more negative, leave air handler on for P3 measurement.
  - If the pressure becomes more positive, turn off air handler for P3 measurement.
- P3** Open CAZ door: \_\_\_\_\_ Pa
- If the pressure becomes more negative, leave CAZ door open.
  - If the pressure becomes more positive, close CAZ door.

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.

<sup>1</sup> If ASHRAE fan has been installed, set to operate at its maximum CFM exhaust rate.

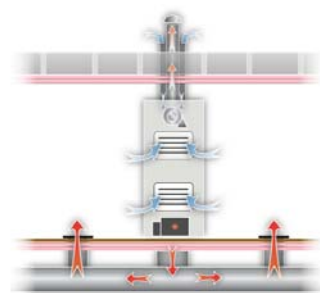
<sup>2</sup> Do not turn on whole house fan if present.

## 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:

- 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<sup>1</sup>.



**Figure 411-1: Typical mobile home downflow furnace**

#### 4111 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.

#### 4112 Furnace Maintenance

Mobile home furnaces should comply with the combustion safety and efficiency standards as discussed in sections 3111 (“Natural Gas and Propane”), 3112 (“Fuel Oil Systems”), 3113 (Electric Heating Systems), 3114 (Wood Burning Safety) and 312 (Combustion Safety Testing).

#### 4113 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.

Inspect the vent for signs of rust, cracks, holes or unsealed or disconnected sections. Repair or replace if necessary.

#### 4114 Ductwork<sup>2</sup>

The following locations have been identified as the most serious duct problems in mobile homes:

<sup>1</sup> See SWS 5.3001.3b, “Alternate Return Air System”

<sup>2</sup> See SWS 3.1602.11c, “Air Sealing System” and SWS 3.1602.12, “Air Sealing System Components”



- Floor and ceiling cavities used as return-air plenums. These return systems should be eliminated and replaced with central return-air<sup>3</sup> through the living space back to the furnace. – see section 41141, “Converting Belly-Return Systems”.



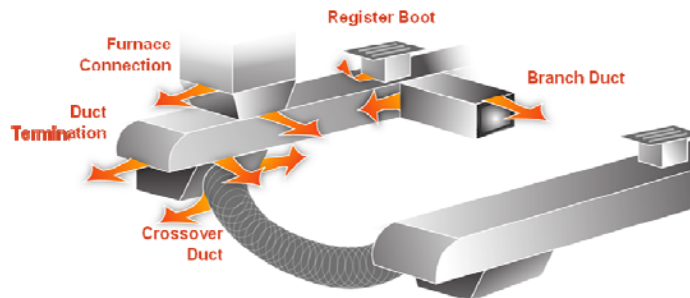
**Figure 4114-1: Opening between duct boot and floor**

- Disconnected, damaged or poorly joined crossover duct – see section 41142.
- The joint between the furnace and the main duct. The main duct may need to be cut open to access and seal these leaks.
- 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 4114-1). Mechanically attach and seal with mastic. If gap is larger than  $\frac{3}{4}$ ", first cover gap with fiberglass mesh tape and then seal with mastic.
- 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 41144, “Duct Leakage Standards”, shall be met.
- See Figure 4114-2 for potential duct leakage locations.

#### 41141 Converting Belly-Return Systems<sup>4</sup>

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<sup>2</sup> 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



**Figure 4114-2: Potential mobile home duct leakage locations**

<sup>3</sup> 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.

<sup>4</sup> See SWS 5.3001.3, “Replace Return Air Systems that Incorporate Floor Cavity (Belly) and/or Attic as the Return Air Pathway”

- 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.
- Duct induced Room Pressures shall be tested once the temperature rise is within the recommended range. See section 115, “Duct-Induced Room Pressure Test”.

#### 41142 Crossover Ducts<sup>5</sup>

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.

Damaged crossover duct work should be replaced. Cut-out damaged sections. Insert and secure metal sleeve between remaining pieces of duct. Mechanically fasten at both inner and outer liner. Seal joints with UL-listed sealant that is durable and structurally sound. Insulate metal sleeve to a minimum R8.

#### 41143 Duct Sealing<sup>6</sup>

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 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.

See section 3153, “Ducts” for additional information regarding duct sealing procedures and methods for improving airflow.

Duct leakage standards shown in section 41144 shall be met.

#### 41144 Duct Leakage Standards<sup>7</sup>

See section 114, “Pressure Pan Duct Test”, for pressure pan test procedures.

Following weatherization work;

- 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 41144-1).



**Figure 41144-1: Initial pressure pan reading of 47 Pa; return duct was totally disconnected**

<sup>5</sup> See SWS 3.1602.9b, “Crossover Ducts”

<sup>6</sup> See SWS 3.1602.11, “Air Sealing System”

<sup>7</sup> See SWS 3.1602.12, “Air Sealing System Components”

#### **412 Mobile Home Water Heaters<sup>8, 9</sup>**

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:

- 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.



**Figure 412-1: Existing mobile home water heater**

#### **413 Mobile Home Air Sealing**

ASHRAE 62.2 shall be used in mobile homes (see sections 112 and 505, "ASHRAE 62.2"). See section 11122, "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.

##### **4131 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.

<sup>8</sup> 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.

<sup>9</sup> See SWS 7.8102.1, "Water Heater Selection"

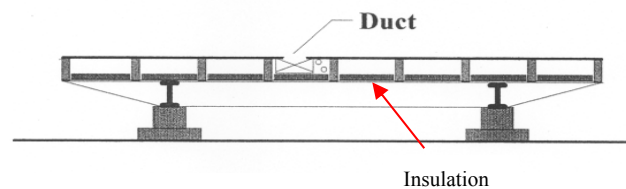
- Gaps around the electrical service panel box, light fixtures, fans and flue pipes.
- Joints between the halves of double-wide mobile homes and between the main dwelling and additions.<sup>10</sup>
- See section 2123, “Bypass Sealing Materials” for information regarding air sealing materials.

#### 414 Mobile Home Floor Insulation

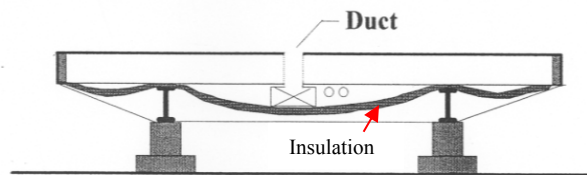
Mobile home floor insulation is a beneficial measure in heating climates. Existing insulation is fastened to the bottom of the floor joists, leaving the cavity uninsulated and subject to convection currents (Figures 414-1 & 2). Mobile home floor cavities may be blown with fiberglass insulation. Alternate floor insulation methods may be done with IHWAP approval.

##### 4141 Mobile Home Floor Preparation<sup>11</sup>

- 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 41141, “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 accessibility<sup>12</sup>. Otherwise, ground moisture barrier is not required for mobile homes.
- Test ducts to ensure that they are tight (see section 4114, “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 41144 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.



**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**

<sup>10</sup> See SWS 3.1101, “Manufactured Housing Walls”

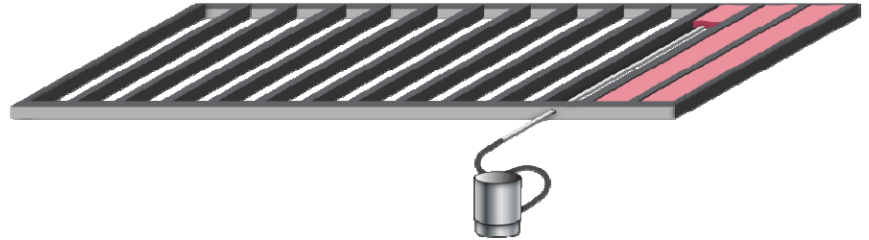
<sup>11</sup> See SWS 4.1302, “Manufactured Housing Belly Preparation”

<sup>12</sup> See SWS 2.0403.4a, “Pier and Skirting Foundation – Ground Moisture Barriers”

- 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.<sup>13</sup>

#### 4142 Floor Insulation<sup>14</sup>

Floor cavities should be insulated with blown fiberglass installed to a density of 1.25 lbs/ft<sup>3</sup> to 1.75 lbs/ft<sup>3</sup>. Batt insulation may be used when repairing and patching mobile home floor cavities. Blown cellulose and rock wool are not to be used.



**Figure 4142-1: Insulating floor cavity from the side where the floor joists run crosswise to the mobile home**

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 4142-1), 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 4142-2), or an end blow.



**Figure 4142-2: Insulating floor cavity from the end where the floor joists run the length of the mobile home (end blow)**

The second method is blowing insulation through a flexible fill tube from holes in the underbelly (belly-board method).

#### 41421 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.

##### *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 (Figure 41421-1). 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



**Figure 41421-1: Blowing a mobile home floor from the side**

<sup>13</sup> See SWS 3.1301, "Penetrations"

<sup>14</sup> See SWS 4.1303, "Manufactured Housing Floor Cavity Insulation"



minimum 3 inch space between the 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 (Figure 41421-2). Insulate half the cavity from each end of the home.

Attach sections of rigid fill tubes as needed to fill each cavity.



**Figure 41421-2: Blowing a mobile home floor from the front**

#### 41422 Belly-Board Method (Figure 41422-1)

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.



**Figure 41422-1: Belly-board method**

### **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 is 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.<sup>15</sup>

#### 4151 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

<sup>15</sup> See SWS 4.1101.5, "Exterior Wall Dense Packing – Preparation"

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, an 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.

#### 4152 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.

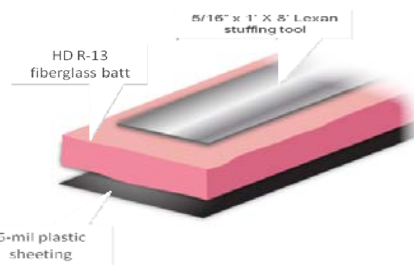
##### 41521 Batt-Stuffing Mobile Home Walls<sup>16</sup>

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 41521-1).

- Use a batt stuffer made of quarter-inch *Lexan*® (polycarbonate plastic), 10 or 11 inches wide and 96 inches long (Figure 41521-2).
- On the ground, lay a piece of plastic sheeting, measuring approximately 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 41521-1: Batt-stuffing a mobile home wall**



**Figure 41521-2: Batt stuffing tool**

<sup>16</sup> See SWS 4.1104.1, “Stuffing Wall Cavities with Fiberglass Batts”

#### 41522 Blowing Mobile Home Walls<sup>17</sup>

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. 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. Additional insulation is blown between existing insulation and interior paneling. Make sure that interior paneling is sound.

#### 416 Mobile Home Roof Cavity Insulation<sup>18</sup>

Blowing a closed mobile home roof cavity is similar to blowing a closed wall cavity, only the insulation does not have to be as dense. Fiberglass blowing insulation is preferred. Cellulose should not be used because of moisture absorption, density and weight.

Venting mobile home roofs is optional. Vent installation may be considered part of an overall strategy to keep moisture out of the roof cavity.

Ensure that electrical problems do not exist in roof cavity before insulating (see section 4151, “Electrical Assessment”).

Occupants of mobile homes in heavy snow load areas should be advised that snow loads will likely increase due to roof cavity insulation. Occupants should be advised not to shovel snow off of the roof, but rather use a push broom if there are concerns.

There are two common methods for blowing mobile home roof cavities. The first is disconnecting the metal roof at its edge and blowing fiberglass through a rigid fill-tube. The second is cutting a square hole in the metal roof and blowing fiberglass through a flexible fill-tube.

#### 4161 Preparation

See section 2131, “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.

- Inspect the ceiling and seal all penetrations.
- Reinforce weak areas in the ceiling.

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<sup>17</sup> See SWS 4.1104.2, “Fiberglass Blown Insulation Installation (Lifting Siding)”

<sup>18</sup> See SWS 4.1003.8, “Installing Fiberglass Blown Insulation for Flat, Bowed, or Vaulted Ceilings (via Roof Side Lift)”

- 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.

#### 41611 Blowing Through the Edge (Figure 41611-1)

This procedure requires a scaffold to be performed safely and efficiently. The roof cavity may have to be accessed from both sides of the mobile home if a “strongback”<sup>19</sup> is present in the roof assembly and the fill tube won’t fit under it. Mobile home metal roofs are usually fastened only at the edge, where the roof joins the wall.

- Remove the screws from the metal j-rail at the roof edge. Also remove staples or other fasteners. Scrape off putty tape.
- Pry the metal roof up far enough to insert a 2 inch diameter, 14 foot long rigid fill tube (Figure 41611-2).
- Blow insulation through the fill-tube into the cavity. Loose blow the last few feet (nearest installer) to prevent insulation from blowing out. Stuff the last foot or two with unfaced fiberglass batts.
- Re-attach roof edge to the wall using new putty tape and larger screws (Figure 41611-3). Re-attach rain gutter.

#### 41612 Blowing Through the Top (Figure 41612-1)<sup>20</sup>

This procedure is not recommended for metal roofs in heavy snow load areas. Instead, install insulation from the roof edge (section 41611) in these areas.

- Cut 10 inch square holes at the roof’s apex on top of every second truss. Each square hole allows access to two truss cavities.
- Existing aluminum roof coating around hole must be removed before new patch is installed. The coating must be heated and then may be scraped-off.
- Use a 2 inch or 2 ½ inch diameter fill-tube. Insert the fill-tube and push it out to within 6 inches of the cavity edge.
- Blow fiberglass insulation into each cavity. Install insulation to a density between 1.25 lbs/ft<sup>3</sup> and 1.75 lbs/ft<sup>3</sup>. Do not overfill cavity.



**Figure 41611-1: Blowing from the edge**



**Figure 41611-2: Blowing roof cavity from edge**



**Figure 41611-3: Re-installing roof gutter with new putty tape**



**Figure 41612-1: Blowing insulation through mobile home roof**

<sup>19</sup> A beam used as a stiffener in some mobile home roofs and floors.

<sup>20</sup> See SWS 4.1003.9, “Installing Fiberglass Blown Insulation for Flat, Bowed, or Vaulted Ceilings (via Exterior Access from Top of Roof)”



- Stuff the area under each square hole with a piece of unfaced fiberglass batt so that the finished patch will stand a little higher than the surrounding roof.
- Patch the hole with a 14 inch square, 26 gauge galvanized steel. Seal with roof cement and screw into the existing metal roof (Figure 41612-2).
- Cover the patch with a second 18 inch square patch of *Peal and Seal*.



**Figure 41612-2: Patch hole with galvanized steel and roof cement**

#### **417 Mobile Home Windows<sup>21</sup>**

##### **4171 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 0.27, a SHGC no lower than 0.42 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.

##### **4172 Mobile Home Storm Windows<sup>22</sup>**

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<sup>23</sup>**

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.

<sup>21</sup> See SWS 3.1201.5, "Manufactured Housing Windows and Doors"

<sup>22</sup> See SWS 3.1201.6, "Interior Storm Windows"

<sup>23</sup> See SWS 3.1201.5, "Manufactured Housing Windows and Doors"



#### **419 Mobile Home Skirting**

Mobile home skirting is not allowed either as a retrofit or repair item. 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 Detectors
- 513 Lead Safe Weatherization Practices
- 514 Code Compliance
- 515 OSHA
- 516 Asbestos
- 517 Hazardous Materials
- 518 Refrigerants
- 519 Injury Prevention
- 520 Radon

### 501 Vermiculite

Vermiculite is a naturally-occurring mineral composed of shiny flakes, resembling mica. 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<sup>1</sup>.

## **502 Ambient Carbon Monoxide (CO) Monitoring**

### **502-1 Requirements**

Assessors and final inspectors shall have a designated ambient CO monitor continuously operating while working in the home (Figure 502-1). Monitors are to be worn near the breathing zone (chest or higher).

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%<sup>2</sup>.



**Figure 502-1: Personal CO monitor**

<sup>1</sup> See SWS 2.0100.1o, "Asbestos Containing Materials (ACM)"

<sup>2</sup> See SWS 2.0201.1a, "Assessment".

## 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)<sup>3</sup>

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.

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<sup>3</sup> See SWS 2.0100.1c, "Global Worker Safety".

## 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<sup>4</sup>

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. 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.

### 5051 Continuous Exhaust Only<sup>5</sup>

All bathroom<sup>6</sup> and kitchen exhaust fans<sup>7</sup> shall meet the following requirements.

- ENERGY STAR rated
- Sone rating no higher than 1.0<sup>8</sup>

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<sup>4</sup> See SWS 6.6201.1, “Installed System Air Flow”

<sup>5</sup> See SWS 6.6003.1, “Surface Mounted Ducted”

<sup>6</sup> This includes bathroom exhaust fans when installed not to meet the ventilation requirements of ASHRAE 62.2-2016.

<sup>7</sup> See section 506, “Kitchen Exhaust Fans”, for exceptions.



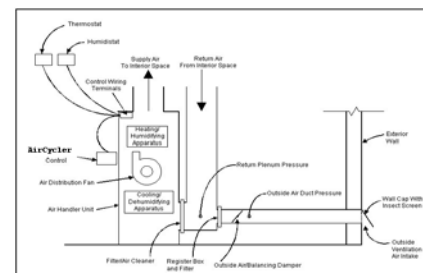
- Rated for continuous operation
- Fans that run on low speed providing the required ventilation with the ability to boost to high speed during period of showering may be used
- Vented to the outside
- Refer to Table 500-1 for proper exhaust fan duct size

The following installation guidelines should be met. Note that some bathroom exhaust fans are not to be installed over bathtubs and shower enclosures – check manufacturer’s installation guidelines.

- 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.<sup>9</sup>
- 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.

#### 5052 Supply-Only Ventilation<sup>10</sup>

A simple supply-only system uses the furnace air handler as the ventilation fan and the heating ducts as the distribution system (Figure 5112-1). 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 5112-1: Supply-only ventilation system**

Duct to the outside shall be sized to provide the required ventilation rate. A motorized damper or equivalent 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.

The air inlet 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 1/2"). Inform client that inlet must be cleaned of dirt and debris on a regular basis.

<sup>8</sup> Maximum sone rating of 1.1 for interior wall mounted exhaust fans.

<sup>9</sup> See SWS 6.6003.1c

<sup>10</sup> See SWS 6.6102.3, "Intakes for Ventilation Air to Forced Air System Used for Heating or Cooling"

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.

#### 5053 Balanced Ventilation<sup>11</sup>

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.

An ERV system is recommended when balanced ventilation is installed in a home that has cooling (Figure 5113-1). 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.

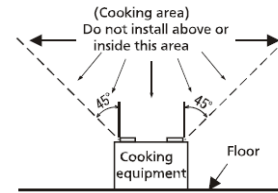
Operation instructions should be posted near the installation to avoid occupant override or misuse.

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<sup>11</sup> See SWS 6.6202.2, “Heat Recovery Ventilator (HRV) and Energy Recovery Ventilator (ERV) Installation”

## 506 Kitchen Exhaust Fans<sup>12</sup>

Any exhaust fan installed in a kitchen must be rated for kitchen use or installed outside the cooking area (Figure 506-1). In addition, exhaust fans installed in kitchens to meet the ventilation requirements of ASHRAE 62.2-2016 must meet 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**

Exhaust fans installed in kitchens that are not used to meet the ventilation requirements of ASHRAE 62.2-2016 must meet the following requirements.

- No sone requirement.
- Fans specifically designed for kitchen use 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<sup>13</sup>

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.
- 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.
- Exhaust fan ducts extending through non-conditioned spaces shall have their joints sealed and are to be insulated to a minimum R8<sup>14</sup> (spray foam insulation may be used).
- Kitchen exhaust fans must be ducted through hard metal and provided with a metal termination cap.

<sup>12</sup> See SWS 6.6005.2 “Kitchen Range”

<sup>13</sup> See SWS 6.6003.1c, d and e, “Surface Mounted Ducted”

<sup>14</sup> See SWS 6.6602.1b

## Exhaust Duct Sizing<sup>15</sup>

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

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.

$$105' - (2 \times 15'_{\text{elbows}}) - (1 \times 30'_{\text{roof cap}}) = 45'$$

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<sup>16</sup>

Disconnected or improperly vented clothes dryer ducts should be corrected as part of weatherization.

- Dryer ducts should be smooth-surfaced aluminum or galvanized rigid duct (Figure 508-1).
- Semi rigid aluminum transition ducts approved for dryer venting may also be used (labeled “Clothes Dryer Transition Duct”, UL 2158A).



**Figure 507-1: Fans may not be vented into the attic under the Weatherization Program**



**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**

<sup>15</sup> From ASHRAE 62.2-2016, “Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings”

<sup>16</sup> See SWS 6.6005.1, “Clothes Dryer”

- 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 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 duct extending through non-conditioned spaces are to be insulated to a minimum R3 (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.

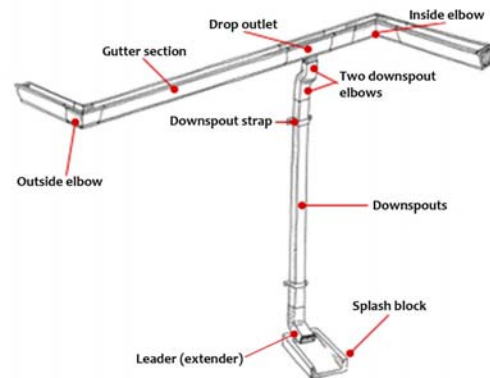


**Figure 508-1: Dryers should be vented with smooth metal duct**

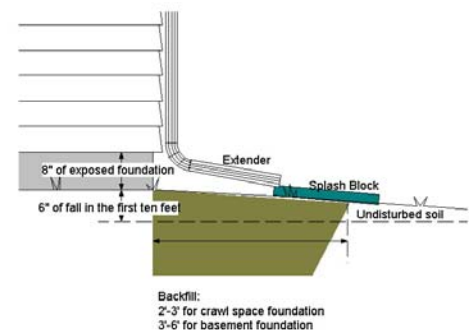
## 509 Gutters and Downspouts

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.

- 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 inch for every 16 feet of run. Short gutters may be hung level. In areas with a 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.
- Downspouts may be oversized to help reduce clogging. Elbows and straight sections should be fastened together



**Figure 509-1 Gutter system**



**Figure 509-1 Water should be directed away from the home**



with pop rivets—screws that project into the downspout can lead to clogging.

- Secure downspouts to house with 3 fasteners.
- 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 5 feet away from homes with basements (Figure 509-2).

## **510 Smoke Detectors**

All houses that are weatherized are required to have at least one working smoke detector in them. Smoke detectors must be installed by the contractor and not left with the client. Batteries are to be replaced in existing operable smoke detectors. Replacement of operable smoke detectors is not permitted.

### **5101 Installation<sup>17</sup>**

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.

Relocate existing smoke detectors as necessary.

### **5102 Operation**

Assure that existing smoke detectors have new batteries. Test all smoke detectors for proper performance following installation.

Hard-wired smoke detectors 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.<sup>18</sup>

### **5103 Client Education**

Review smoke detector testing procedures with clients following alarm installation and advise regarding battery replacement as appropriate.

### **5104 Specifications**

- Smoke detectors that are powered by a battery must emit a signal when the battery is losing power.

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<sup>17</sup> See SWS 2.0301.1, “Smoke Alarm”

<sup>18</sup> See SWS 2.0301.1a

- All installation hardware, including a screw mounting bracket, should be included with the alarm.
- Smoke detectors must be approved by Underwriters Laboratories (UL).

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.

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 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.



**Figure 511-1: Fire extinguisher**

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<sup>19</sup>

All homes that receive Weatherization work shall receive carbon monoxide alarms regardless of the space heating fuel type.

CO alarms should be installed according Illinois Public Act 094-0741 in all homes.

In addition, carbon monoxide alarms should 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.

A summary of Illinois Public Act 094-0741 with regard to type and placement of CO alarms is provided here.

<sup>19</sup> See SWS 2.0301.2, “Carbon Monoxide Alarm or Monitor”

### 5121 Type

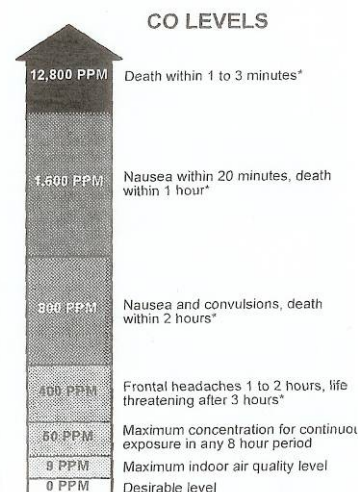
Minimum CO alarm type shall be plug-in with battery back-up. Combination smoke and CO detectors are not permitted.

### 5122 Location and Placement

CO alarms are to be installed on each separate living level of the home where household members frequently spend time. CO alarms must also be installed in any room with a wood-burning fireplace. It is not necessary to install a CO alarm in an unfinished basement.

Do not install alarms in the following areas:

- Near bathrooms or in shower areas,
- In closets,
- Crawl spaces or unheated areas where extreme hot or cold temperatures occur,
- 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.



**Figure 512-1: Health effects from elevated CO levels**

### 5123 Specifications

CO alarms shall:

- Meet or exceed UL2034-98 and/or IAS696 standards.
- Have a manual test and reset button.
- Have a five-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.

### 5124 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 512-1).

## 513 Lead Safe Weatherization Practices<sup>20</sup>

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.

<sup>20</sup> See SWS 2.0100.1p, "Global Work Safety – Lead Paint Assessment"

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.

### 5131 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

### 5132 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:

- 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 5132-1).
- 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.



**Figure 5132-1: Use hand tools whenever possible**

### 5133 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

#### 5134 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.

#### 5135 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.

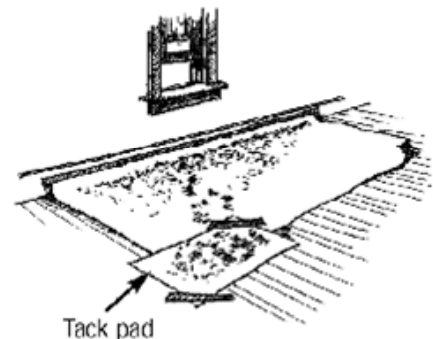
If workers use the resident's facilities for personal cleanup, these facilities should be thoroughly cleaned at the end of each work day.

#### 5136 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).



**Figure 5136-1: Level 1 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<sup>2</sup> of 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



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 5136-1). 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<sup>2</sup> of surface is disturbed, that space should be placed under full containment (Figure 5136-2).



**Figure 5136-2: Level 2 Containment**

Typical weatherization tasks requiring Level 2 Interior Containment 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 5136-3: Exterior Containment**

#### *Exterior Containment*

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.

#### **5137 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.

### 5138 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.

### 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**

Whenever site conditions permit, exposed dirt must be covered with a vapor barrier (6 mil polyethylene sheeting) except for mobile homes (see section 2154, "Ground Moisture Barrier").

Covers may be installed on open sump pits and sealing below grade foundations cracks may also be found as radon mitigation measures.

## Appendix 601 – “Add-a-Hole Method”

The “Add-a Hole” Method may be used 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 “ZPD” (Zone Pressure Diagnostics) spreadsheet. The use of the ZPD spreadsheet is described here.

- A. Enter the house pressure, air flow and zone pressure numbers (50 Pa, 3900 CFM50 and 4.5 Pa in the example below<sup>1</sup>).
- B. Make opening between house and zone (attic hatch, for example) or zone to outside (exterior hatch to crawl space, for example).
- C. Bring house to 50 Pa (or lower pressure if zone is too leaky), enter CFM50 and new zone pressure number. If the pressure didn’t change by more than 6.0 Pa, make opening larger.
- D. Read results. For example below:

Total area of all attic bypasses:	148 in <sup>2</sup>
Total area of all attic vents and other openings in roof:	617 in <sup>2</sup>
Maximum CFM50 reduction if all attic bypasses are sealed:	1382 CFM50

A. Original house pressure, CFM50 and attic zone pressure	Input:	Zone A:	attic		
		Blower door test 1a, reference to outdoors			
		House pressure		50 Pa	
		Air flow		3900 cfm50	
B. Indicate zone opening to inside or	Input:	Zone pressure		4.5 Pa	
		Blower door test 2a, reference to outdoors			
		Opening: zone to...		inside	
		House pressure		50 Pa	
C. New house pressure, CFM50 and attic zone pressure after opening hole	Output:	Air flow		6780 cfm50	
		Zone pressure		28.6 Pa	
		Opening area	House to attic		148 in2
			attic to outdoor		617 in2
Max. reduction			1382 cfm50		
D. Results					

<sup>1</sup> Note that zone pressures are entered without the “-” sign; simply enter the zone pressure number.