

# Retrofitting Washington



**Department of Commerce**  
Innovation is in our nature.

Standard Work Specifications  
Field Guide for **Single-Family  
and Manufactured Homes**

created by

Washington Department of Commerce

Revised 2/25/19

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\*\*\*Tip: Clicking on the [blue SWS numbers](#) below will bring you to that SWS on the NREL website\*\*\*

## 2.0100.1b - Hand Protection

### Desired Outcome:

Work completed safely without injury or hazardous exposure

### Specifications:

Durable and wrist-protecting gloves will be worn that can withstand work activity

### Objective(s):

Minimize skin contact with contaminants

Protect hands from sharp objects



**Unsafe**

Recognize potential risks



**Safe**

Wear appropriate hand protection

## 2.0100.1b - Hand Protection



GOOD: Wear nitrile gloves when handling mastic



Inspect gloves for holes and damage to minimize risk

## 2.0100.1c - Respiratory Protection

### Desired Outcome:

Work completed safely without injury or hazardous exposure

### Specification(s):

If the risk of airborne contaminants cannot be prevented, proper respiratory protection will be provided and worn (e.g., N-95 or equivalent face mask)

When applying low pressure 2-component spray polyurethane foam, air purifying masks with an organic vapor cartridge and P-100 particulate filter will be used

When applying high-pressure SPF insulation, supplied air respirators (SARs) will be used

Consult MSDSs for respiratory protection requirements

### Objective(s):

Minimize exposure to airborne contaminants (e.g., insulation materials, mold spores, feces, bacteria, chemicals)



### Unsafe

Workers face health risks without the proper respirators.



### Best Practice

Retrofits can have multiple different respiratory protection requirements, depending on materials being installed

## 2.0100.1c - Respiratory Protection



Whenever airborne contaminants are a possibility, wear an N-95 mask



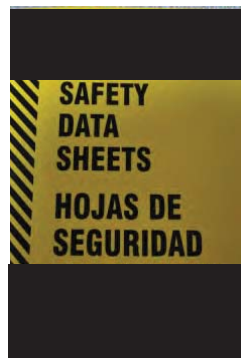
For two-component spray insulation, P-100 respirators should be used



All P-100s should be fitted to the individual worker



When working with high-pressure spray foam, use a Supplied Air Respirator



When unsure what level of protection is necessary, check the SDS

## 2.0100.1d - Electrical Safety

### Desired Outcome:

Work completed safely without injury or hazardous exposure

### Specification(s):

An electrical safety assessment will be performed

All electric tools will be protected by ground-fault circuit interrupters (GFCI)

Three-wire type extension cords will be used with portable electric tools

Worn or frayed electrical cords will not be used

Water sources (e.g., condensate pans) and electrical sources will be kept separate

Metal ladders will be avoided

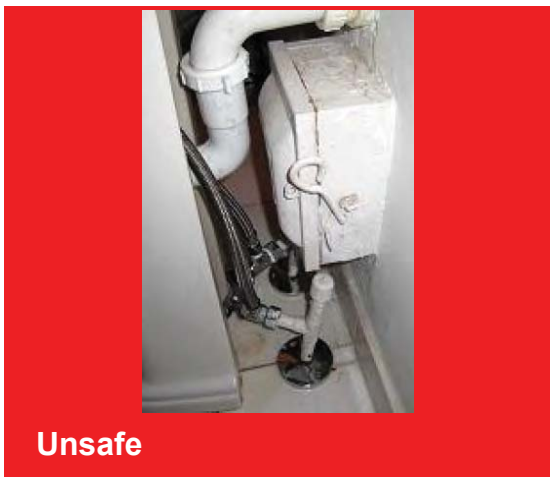
Special precautions will be taken if knob and tube wiring is present

Aluminum foil products will be kept away from live wires

For arc flash hazards, NFPA 70E will be consulted

### Objective(s):

Avoid electrical shock and arc flash hazards



Inspect house for unsafe electrical situations



Attics and crawl spaces should be inspected closely for electrical safety before work begins

## 2.0100.1d - Electrical Safety



Use GFCIs and three-wire extension cords for all power tools



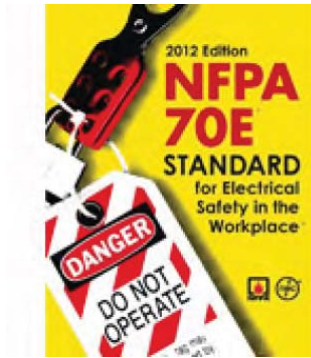
Electrical wiring should not be located near a water source



Use fiberglass ladders in place of metal



Recognize if knob and tube wiring is present and take special precautions



Follow NFPA 70E 2012 guidelines for arc flash hazards

## 2.0100.1e - Carbon Monoxide (CO)

### Desired Outcome:

Work completed safely without injury or hazardous exposure

### Specification(s):

All homes will have a carbon monoxide alarm

Ambient CO will be monitored during combustion testing and testing will be discontinued if ambient CO level inside the home or work space exceeds 35 parts per million (ppm)

### Objective(s):

Protect worker and occupant health



**Unsafe**

STOP WORK if CO levels are higher than 35ppm!!



**Best Practice**

Install carbon monoxide alarms

### Tools:

1. Personal Carbon Monoxide (CO) monitor during combustion safety testing

### Materials:

1. Carbon Monoxide (CO) alarm

Carbon Monoxide (CO) Detectors: Local agencies shall install a minimum of one carbon monoxide (CO) detector per floor in every dwelling unit where detectors are not present or are inoperable. Replacement of operable CO detectors is not an allowable cost. CO detectors shall be installed in accordance with manufacturer's requirements. a. Detector standards: Detectors shall have:

- (1) A 5-year warranty for residential models or 1-year warranty for commercial low-level models.
- (2) An electrochemical sensor.

- (3) A digital display that indicates CO levels in Parts Per Million (ppm).
- (4) The capability to accurately detect and display low levels of carbon monoxide to 15 ppm.
- (5) A label to verify testing and listing to the UL 2034 Standard.

Exception: CO Detectors need not be UL listed if a low level detector is desired. To comply with this exception, these commercial low-level detectors must meet or exceed all of the following:

- (a) ACGIH and NIOSH Standards.

## 2.0100.1f - Protective Clothing

### Desired Outcome:

Work completed safely without injury or hazardous exposure

### Specification(s):

MSDSs and OSHA regulations will be consulted for protective clothing and equipment

Eye protection will always be worn (e.g., safety glasses, goggles if not using full-face respirator)

### Objective(s):

Protect worker from skin contact with contaminants

Minimize spread of contaminants



 Before

Workers should be aware of work required and dress appropriately



 After

Ensure workers have proper protective equipment for work environment

## 2.0100.1g - Confined Space Safety

### Desired Outcome:

Work completed safely without injury or hazardous exposure

### Specification(s):

Access and egress points will be located before beginning work

Inspection will be conducted for frayed electrical wires

Adequate ventilation will be provided

Use of toxic material will be reduced

### Objective(s):

Prevent build-up of toxic or flammable contaminants

Provide adequate access and egress points

Prevent electrical shock



👍 After

Locate all access and egress points of confined spaces before entering

## 2.0100.1g - Confined Space Safety



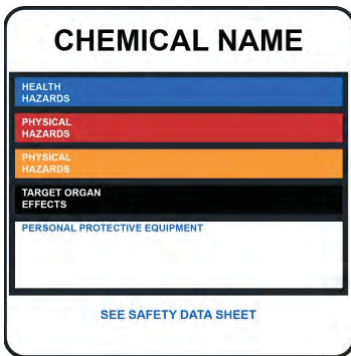
Perform visual inspection of confined spaces before beginning work



Check for frayed or worn electrical wires



In confined spaces, use a ventilator



Check GHS labels and Safety Data Sheets for all materials to minimize hazards

## **2.0100.1h - Power Tool Safety**

### **Desired Outcome:**

Work completed safely without injury or hazardous exposure

### **Specification(s):**

Power tools will be inspected and used in accordance with manufacturer specifications and OSHA regulations to eliminate hazards such as those associated with missing ground prongs, ungrounded circuits, misuse of power tools, noise, and improper or defective cords or extension cords

All devices used will be verified as GFCI protected or double insulated

Exhaust gases from compressors and generators will be prevented from entering interior space

### **Objective(s):**

Prevent power tool injuries

## 2.0100.1j - Ergonomic Safety

### Desired Outcome:

Work completed safely without injury or hazardous exposure

### Specification(s):

Appropriate PPE will be used (e.g., knee pads, bump caps, additional padding)

Proper equipment will be used for work

Proper lifting techniques will be used

### Objective(s):

Prevent injuries from awkward postures, repetitive motions, and improper lifting



**Unsafe**

Workers will take precautions to protect themselves on the job site



**Best Practice**

Hard hats, knee pads, bump caps, and team lifts help to prevent injury

## 2.0100.1m - Heat and Thermal Stress

### Desired Outcome:

Work completed safely without injury or hazardous exposure

### Specification(s):

Ensure staff is aware of risks during summer months, including the symptoms of heat stroke and heat exhaustion

Appropriate ventilation, hydration, rest breaks, and cooling equipment will be provided

911 will be dialed when necessary

### Objective(s):

Prevent heat stroke, heat stress, and cold stress related injuries



Attics and crawl spaces can be dangerous work places in the heat



Keep workers comfortable with hydration and cool vests

Excessive heat easily builds up in attic spaces. When the heat in these spaces is enough to overcome a worker and prevent them from exiting without assistance, it is known as a thermal hazard. Prevent worker exposure to thermal hazards with the following measures:

- reduce the temperature in the space with mechanical ventilation.
- ensure workers are drinking plenty of water
- workers will wear *cool vests*
- reschedule work for times when those spaces do not present thermal hazards

## 2.0100.1p - Lead Paint Assessment

### Desired Outcome:

Work completed safely without injury or hazardous exposure

### Specification(s):

Presence of lead based paint in pre-1978 homes will be assumed unless testing confirms otherwise

The Environmental Protection Agency (EPA) Renovation, Repair, and Painting (RRP) Program Rule (40 CFR Part 745) in pre-1978 homes and proposed changes to this rule (Federal Register/Vol. 75, No. 87/May 6, 2010) will be complied with, to be superseded by any subsequent final rulemaking or any more stringent state or federal standards

### Objective(s):

Protect workers and occupants from potential lead hazards



Exterior lead containment elements



EPA-recognized Lead Test Kit

### Tools:

1. PPE
2. Containment tools
3. HEPA Vacuum
4. Lead safe engineering controls

### Materials:

1. EPA approved Lead test kit
2. Containment materials: caution tape, signs, poly

## 2.0104.1b - Vermiculite

### Desired Outcome:

Work is completed safely without injury or hazardous exposure

### Specification(s):

OSHA asbestos abatement protocol 29 CFR 1926.1101 will be followed if vermiculite insulation is present

If unsure whether material contains asbestos, a qualified asbestos professional will be contacted to assess the material and to sample and test as needed

When working around asbestos-containing material (ACM), the following will not be done:

- Dust, sweep, or vacuum debris
- Saw, sand, scrape, or drill holes in the material
- Use abrasive pads or brushes to strip materials

Attic insulation that looks like vermiculite (as opposed to fiberglass, cellulose, or urethane foams) will not be removed or disturbed

### Objective(s):

Protect workers from toxic exposure



Material identified as vermiculite may contain asbestos



If asbestos is suspected, call an EPA-accredited professional

Note: It is assumed Vermiculite is an Asbestos Containing Material (ACM) since sample testing protocols of a non homogeneous material are unable to "prove" absence of Asbestos in all the material present.

Removal of vermiculite in attics shall be done by certified Asbestos professionals licensed by the state of Washington Labor and Industry in accordance WAC 296-65-010 workers, 296-65-012 supervisors, 296-65-017 certified firms

The Zonolite Vermiculite Insulation Trust has been established to assist homeowners with cost of removal of Zonolite insulation in attics. The Trust will also assist with cost of reinsulating attic. See link for additional information <http://www.zonoliteatticinsulation.com/claim-form/>

## 2.0104.1b - Vermiculite



Do not disturb vermiculite by vacuuming, dusting, or sweeping



Do not disturb vermiculite by drilling, sanding, scraping, sawing, etc.

## 2.0105.1c - Raw Fuel

### Desired Outcome:

Work completed safely without injury or hazardous exposure

### Specification(s):

Raw fuel leaks will be monitored for before entering building spaces

If leaks are found, testing will be discontinued and condition reported to occupant immediately

### Objective(s):

Protect worker and occupant health



 Before

Fuel leaks need to be repaired by appropriate professional



 After

Notify occupant of any leaks

### Tools:

1. Gas sniffer
2. Bubble solution

## 2.0105.1c - Raw Fuel



Check all raw fuel lines for leaks



Use multiple methods to test for leakage--bubble solution



If bubbles develop, leak is present. Notify occupant



Any leaks found should be reported to occupant and work stopped



Any leaks found should be reported to occupant and work stopped

## 2.0105.2c - Asbestos

### Desired Outcome:

Work completed safely without injury or hazardous exposure

### Specification(s):

Identify asbestos hazards in boiler and pipe insulation and remediate in accordance with EPA guidelines

### Objective(s):

Protect workers and occupants from asbestos exposure



**Unsafe**

Suspicious pipe insulation may contain asbestos



When asbestos is suspected, call in EPA-accredited professionals.

## 2.0105.2b - Mercury

### Desired Outcome:

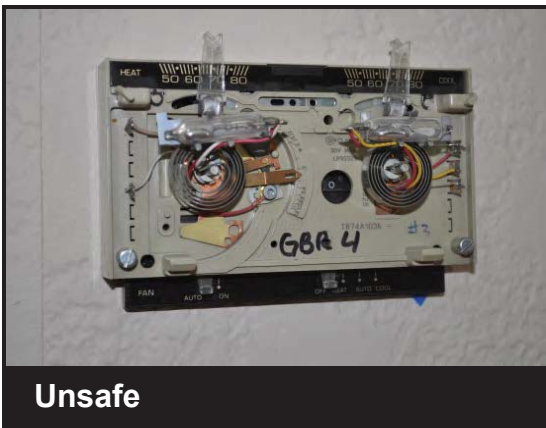
Work completed safely without injury or hazardous exposure

### Specification(s):

When replacing existing thermostats, identify and dispose of any mercury containing thermostats in accordance with Environmental Protection Agency (EPA) guidance

### Objective(s):

Protect workers and occupants from mercury exposure



**Unsafe**

Mercury thermostats should be replaced and disposed of properly



**Unsafe**

Do NOT dispose of mercury thermostats in the trash--find local recycling

Paraphrased from 40 CFR 273.14: A universal waste mercury-containing thermostat or container containing only universal waste mercury-containing thermostats should be labeled or marked clearly with any of the following phrases: "Universal Waste-Mercury Thermostat(s)," "Waste Mercury Thermostat(s)," or "Used Mercury Thermostat(s)." \*\*Contact [thermostat-recycle.org](http://thermostat-recycle.org) or [earth911.org](http://earth911.org) for recycling options.

# 4.1005.2d, 4.1301.1d, 4.1103.1b - Onsite Documentation

### Desired Outcome:

Consistent, thermal boundary between conditioned and unconditioned space controls the heat flow

### Specification(s):

A dated receipt signed by the installer will be provided that includes:

- Insulation type
- Coverage area
- R-value
- Installed thickness and settled thickness
- Number of bags installed in accordance with manufacturer specifications

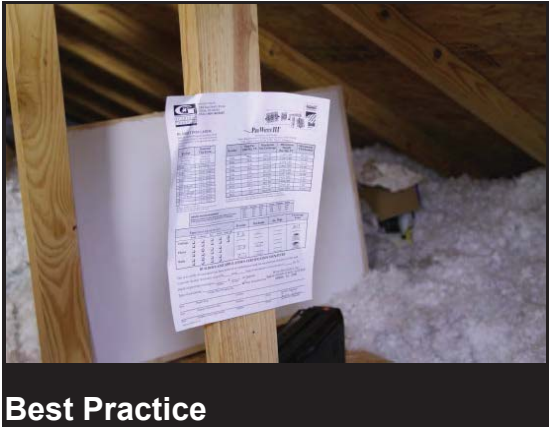
### Objective(s):

Document job completion to contract specifications

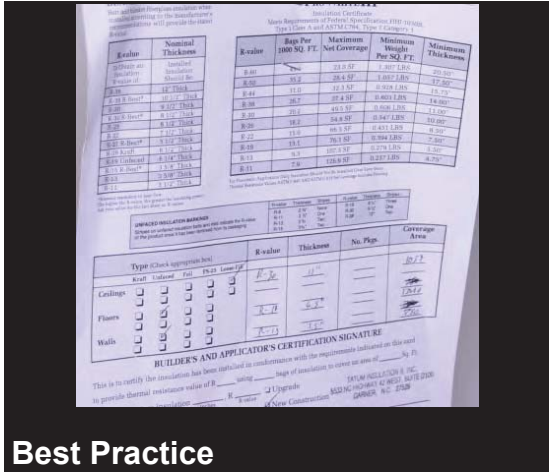
Confirm amount of insulation installed

Ensure ability to match bags required for total area completed

Comply with 16 CFR 460.17



**Best Practice**



**Best Practice**

Information on insulation installed should be posted nearby

Posted info includes insulation type, r-value, depth, coverage area, etc.

This requirement applies whenever insulation is installed.

Reference 16 CFR 460.17: The installer, must provide the customer or client documentation regarding the insulation installed. Documentation will indicate the coverage area, thickness, and

R-value of the insulation. The insulation certification must be dated and signed by the installer. Insulation certificate to be posted at entrance to attic or crawlspace and a copy shall be provided for project file.

To figure out the R-value of the insulation, use the data that the manufacturer gives you.

## Occupant Education>Forced Air systems Single-Family Homes

Title	Specification(s)	Objective(s)	
5.3003.7a Basic operation	Basic operation of the equipment will be explained to the occupant (e.g., design conditions, efficiency measures, differences from previous system or situation)	Ensure occupant has a reasonable expectation of the equipment's capability	
5.3003.7b System controls (e.g., thermostat, humidistat)	Proper operation and programming of system controls to achieve temperature and humidity control will be explained to the occupant	Ensure occupant can operate system controls	
5.3003.7c System disconnects	Indoor and outdoor electrical disconnects and fuel shut-offs will be demonstrated to occupant	Ensure occupant can shut off equipment in emergencies	
5.3003.7d Combustion air inlets	<p>Location of combustion air inlets will be identified for occupant in accordance with NFPA 31, 54, and 58</p> <p>Importance of not blocking inlets will be explained to occupant</p>	Ensure occupant does not block combustion air inlets	

## Occupant Education>Forced Air systems Single-Family Homes

Title	Specification(s)	Objective(s)	
<p>5.3003.7e Blocking air flow</p>	<p>Importance of cleaning dust and debris from return grilles will be explained to occupant</p> <p>Proper placement of interior furnishings with respect to registers will be explained to occupant</p> <p>Negative consequences of closing registers will be explained to occupant</p> <p>Importance of leaving interior doors open as much as possible will be explained to occupant</p>	<p>Ensure occupant does not prevent equipment from operating as designed</p>	

## Occupant Education>Forced Air systems Single-Family Homes

	Title	Specification(s)	Objective(s)	
	5.3003.7f Routine maintenance	<p>Proper filter selection and how to change the filter will be explained to occupant</p> <p>Importance of keeping outside unit clear of debris, vegetation, decks, and other blockage will be explained to occupant</p> <p>Importance and timing of routine professional maintenance will be explained to occupant</p> <p>There will be no air bypass around the filters and new central forced air HVAC systems will have minimum MERV 6 filtration</p>	Ensure equipment operates as designed	

## Occupant Education>Forced Air systems Single-Family Homes

Title	Specification(s)	Objective(s)	
5.3003.7g Calling heating, ventilation, and air conditioning (HVAC) contractor	Situations when the occupant should contact the HVAC contractor will be explained, including: <ul style="list-style-type: none"> <li>• Fuel odors</li> <li>• Water draining from secondary drainline</li> <li>• Emergency heat indicator always on for a heat pump system</li> <li>• System blowing cold air during heating season and vice versa</li> <li>• Icing of the evaporator coil during cooling mode</li> <li>• Outside unit never defrosts</li> <li>• Unusual noises</li> <li>• Unusual odors</li> </ul>	Notify occupant to contact installer when system is not operating as designed	
5.3003.7h Carbon monoxide (CO)	A carbon monoxide (CO) alarm will be installed	Occupant will be made aware of operation of CO alarm	
5.3003.7i Warranty and service	Occupant will be provided with relevant manuals and warranties  The labor warranty will be explained and the occupant will be given a phone number to call for warranty service	Provide manuals and warranties for future servicing	

## 6.6202.1e - Occupant Education>Ventilation

### Desired Outcome:

Fan controls support ventilation strategy

### Specification(s):

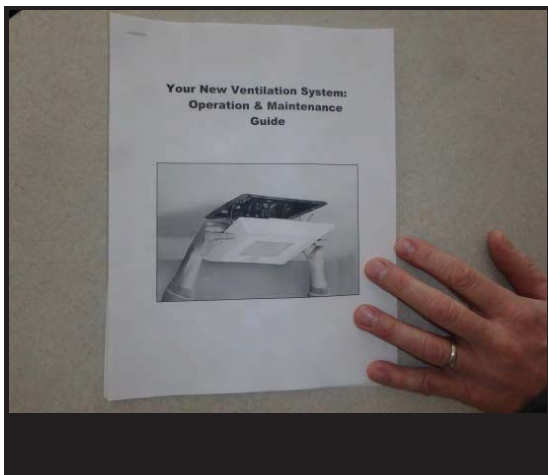
A system operation guide designed for occupants (non-professionals) will be provided to explain how and why to operate system

A label indicating the presence and purpose of the ventilation system will be included or a copy of the system operation guide will be posted at the electrical panel

### Objective(s):

Educate occupants about system operation and importance

Deliver intended air exchange



Ventilation system operation guide for occupants



A labeled switch for manual override

SWS 6.6202.1d - A labeled switch for manual override to be included for the ventilation system.

Locations suitable for the manual override label include:

- Switch plate
- Breaker panel
- Fan housing

## 6.6005.1e - Occupant Education>Dryer Vent Maintenance

### Desired Outcome:

Dryer air exhausted efficiently and safely

### Specification(s):

Occupant will be instructed to keep lint filter and termination fitting clean

Occupant will be instructed to keep dryer booster fan clean, if present

Occupant will be instructed on clothes dryer operation safety including information on items that must not be placed in the clothes dryer (items with any oil or other flammable liquid on it, foam, rubber, plastic or other heat-sensitive fabric, glass fiber materials)

### Objective(s):

Effectively move air from clothes dryer to outside



**Unsafe**

Neglect of clothes dryer maintenance can cause fire hazards



**Best Practice**

Occupants should be taught to clean lint filters and termination fittings

## 6.6005.1e - Occupant Education>Dryer Vent Maintenance



In homes with booster fans, occupant should know location and how to clean



Occupants should be taught never to put flammable articles in dryer (in this case, oily rags)

## 2.0201.1a - Assessment

### Desired Outcome:

Accurate information about appliance safe operation is gathered

### Specification(s):

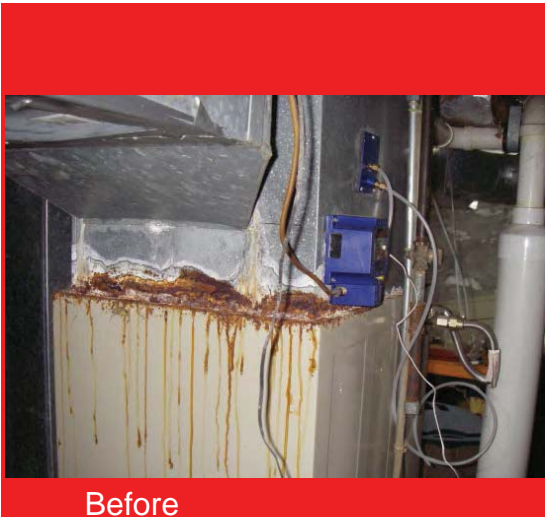
Emergency problems (e.g., ambient gas levels greater than 10% Lower Explosion Limit (LEL), ambient CO levels that exceed 70 ppm) will be communicated clearly and immediately to the customer, the home shall be evacuated, and appropriate personnel (e.g.: HVAC technician, utility, emergency services) shall be contacted.

Significant problems (e.g., gas leak less than 10% LEL, ambient CO levels that exceed 35 ppm but less than 70 ppm) will be communicated clearly and immediately to the customer and appropriate solutions will be suggested

Examine appliance for signs of damage, misuse, improper repairs, and lack of maintenance

### Objective(s):

Ensure system does not have potentially fatal problems



Unsafe combustion appliances indicate need for repair or replacement



In cases of replacement, ensure new appliance is safe and sized properly

Follow State of Washington combustion safety testing protocols found in Appendix A

## 2.0201.1a - Assessment



Assess existing combustion appliances for damage and replace when necessary



When a simple filter cleaning or replacement will help, make it happen



Ensure there is adequate make-up air -- combustion air inlet in closet



Stop the misuse of combustion appliances -- here an unvented propane heater is found inside



Keep occupant apprised of any health or safety concerns

## 2.0201.1b - Fuel Leak Detection

### Desired Outcome:

Accurate information about appliance safe operation is gathered

### Specification(s):

Inspect and test for gas or oil leakage at connections of natural gas, propane piping, or oil systems

If leaks are found, immediate action will be taken to notify occupant to help ensure leaks are repaired

The report will specify repair for leaks and replacement for hazardous or damaged gas or oil connectors and pipes

### Objective(s):

Detect fuel gas leaks

Determine and report need for repair



 Before

Fuel lines should be inspected for leakage



 After

If leaks are found, notify occupant immediately to facilitate repair

### Tools:

1. Gas sniffer
2. Spray bottle

### Materials:

1. Bubble solution

## 2.0201.1b - Fuel Leak Detection



Inspect exterior gas and oil lines for leaks and damage



Inspect flex lines for damage, and check date on ring for pre-1973 hardware

## 2.0201.1c - Venting

### Desired Outcome:

Accurate information about appliance safe operation is gathered

### Specification(s):

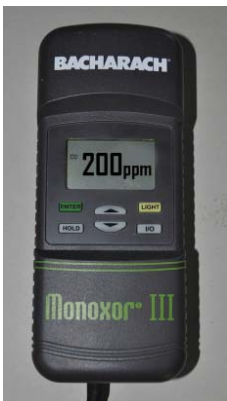
For oil systems that require a draft regulator, the presence and operability of it (that draft regulator) will be verified and tested.

Combustion venting systems will be inspected for damage, leaks, disconnections, inadequate slope, and other safety hazards

### Objective(s):

Determine if a regulator is present and working

Determine whether vent system is in good condition and installed properly



### Unsafe

if ventilation system puts occupants at risk, it needs immediate attention



### Safe

Properly vented appliances make a house healthier and more efficient



Determine if a draft regulator is installed and working



Inspect ventilation systems for damage



Inspect ventilation systems for disconnected pipes



Inspect ventilation systems for inadequate slope



Inspect for missing draft diverter

**Clearance to Combustibles for Combustion Appliance Vents**

Fuel	Vent type	Minimum Clearance to combustibles
Gas, LP	Type B gas vent	1"
	Single wall metal	6"
Fuel Oil	Type L vent	9"
	Single wall metal	18"
Solid Fuel	Type L vent	9"
	Single wall metal	18"
Pellet fuel	Type L vent	per manufacturer's Specification

All combustion appliances vents and flues must maintain clearance to combustibles.

## 2.0201.2a - Outside Combustion Make-Up Air

### Desired Outcome:

Buildup of dangerous combustion byproducts in the living space prevented

### Specification(s):

Where applicable, combustion air will be provided from the outside and installed in accordance with the IRC for the type of appliance installed

### Objective(s):

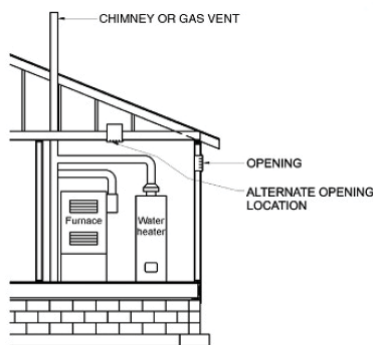
Prevent combustion byproducts from entering the house

When adding combustion air there are 3 options:

Image 1: For homes with one permanent opening, see 2012 IRC: G2407.6.2 (304.6.2): a minimum free area of 1 in<sup>2</sup> per 3,000 Btu/h (734 mm<sup>2</sup>/kW) of total input rating of all appliances

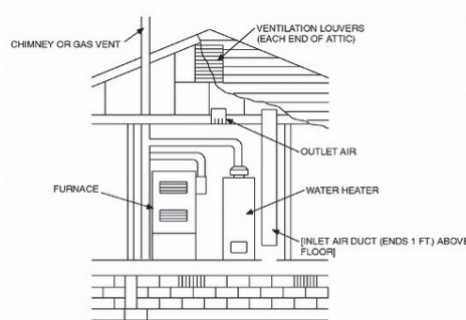
Image 2: For homes with two permanent vertical duct openings, see 2012 IRC G2407.6.1 (304.6.1): a minimum free area of 1 in<sup>2</sup> per 4,000 Btu/h (550 mm<sup>2</sup>/kW) of total input rating of all appliances

Image 3: For homes with two permanent horizontal duct openings, see 2012 IRC G2407.6.1(304.6.1): a minimum free area of 1 in<sup>2</sup> per 2,000 Btu/h (1,100 mm<sup>2</sup>/kW) of total input rating of all appliances



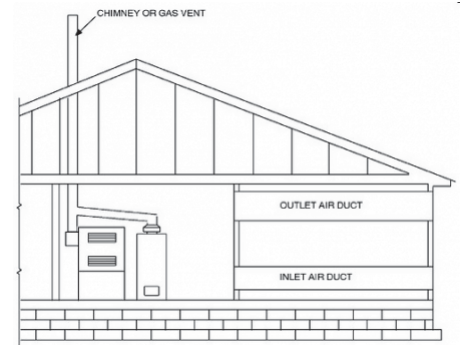
1

min free area of 1 sqin per 3,000 Btu/h(734 mm<sup>2</sup>/kW) of total input rating



2

min free area of 1 sqin per 4,000 Btu/h (550 mm<sup>2</sup>/kW) of total input rating



3

min free area of 1 sqin per 2,000 Btu/h(1100 mm<sup>2</sup>/kW) of total input rating

## 2.0201.2b - New Appliances

### Desired Outcome:

Buildup of dangerous combustion byproducts in the living space prevented

### Specification(s):

New appliance will be installed in accordance with manufacturer specifications, 2012 IRC G2427.8, and additional applicable codes

Replacement equipment venting will be assessed to ensure other existing equipment is not adversely affected

### Objective(s):

Prevent combustion byproducts from entering the house



 Before

Damaged combustion appliances beyond repair should be replaced



 After

Sealed-combustion, direct-vent appliances should replace unsafe appliances

## 2.0201.2b - New Appliances



Two-pipe 90% efficiency furnaces, and other sealed combustion, direct vent appliances are viable replacement appliances

## 2.0201.2d - Gas ovens

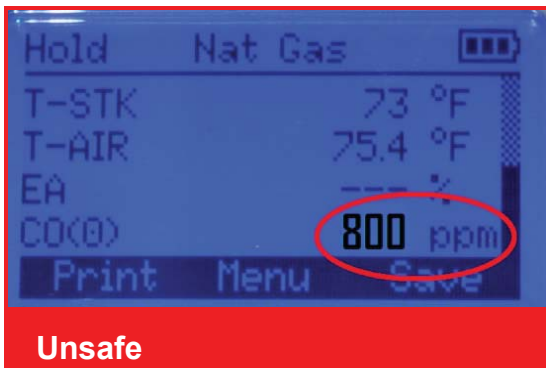
### Specification(s):

Gas ovens will be tested for CO

A clean and tune will be conducted if measured CO in the undiluted flue gases of the oven vent at steady state exceeds 225 ppm as measured

### Objective(s):

Ensure clean burn of gas ovens



If CO exceeds 225ppm as measured, order a clean and tune



Test gas oven for carbon monoxide using a combustion gas analyzer

### Tools:

1. Combustion analyzer with probe

For gas range burners: specify clean and tune if the flame has any discoloration, flame impingement, an irregular pattern, or if burners are visibly dirty, corroded, or bent.

## 2.0201.2e - Gas Range Burners

### Desired Outcome:

Buildup of dangerous combustion byproducts in the living space prevented

### Specification(s):

Recommend clean and tune if the flame has any discoloration, flame impingement, or an irregular pattern or if burners are visibly dirty, corroded, or bent

### Objective(s):

Ensure clean burn and operation of gas range burners



 Before

Discoloration is a clear sign that a gas range needs a clean and tune



 After

A properly operating gas range burner should have an even blue flame

## 2.0201.2e - Gas Range Burners



Yellow, uncontrolled flames indicate the need for a clean and tune



Gas ranges should be cleaned and tuned if improper operation is evident



Blue, even flames indicate burners are working properly

## 2.0201.2f - Solid Fuel Burning Appliances

### Desired Outcome:

Buildup of dangerous combustion byproducts in the living space prevented

### Specification(s):

If the solid fuel burning appliance is the primary heat source and has signs of structural failure replace solid fuel burning appliance with UL-listed and EPA - certified appliances if the existing appliance is not UL-listed

### Objective(s):

Ensure safe operations of solid fuel burning appliances



Unsafe solid fuel burning appliances should be replaced



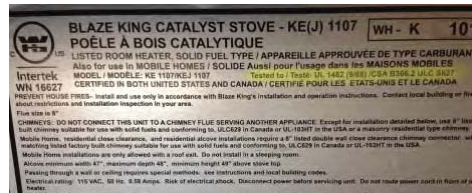
New appliances should be UL-listed and EPA-certified

1. New wood stoves installed on or after May 15, 2015, must meet EPA emission requirements and be certified to not discharge into the atmosphere any gases that contain particulate matter in excess of a weighted average of 4.5 g/hr.
2. Washington State Dept. of Commerce requires completion of the Solid Fuel Burning Appliance Systems Supplemental Audit Form when repairing or replacing wood stoves.
3. Wood stoves installed in mobile homes shall be rated for use in mobile homes. Follow all manufacturer's installation specifications, especially regarding venting, mounting surfaces, and distance to surrounding surfaces.

## 2.0201.2f - Solid Fuel Burning Appliances



Locate data plate to find out appliance ratings



Check appliance rating plates for EPA and UL markings  
(or CSA, ETL, or WH markings)

## 2.0201.3a - Spillage Test

### Desired Outcome:

Accurate information about appliance safe operation is gathered

### Specification(s):

In conditions with largest negative pressure as determined from Detail 2.0201.1e:

If spillage in a combustion appliance with a warm vent exceeds two minutes during pressure testing, specify measures to mitigate

If spillage in a combustion appliance with a cold vent exceeds five minutes during pressure testing, specify measures to mitigate

### Objective(s):

Detect excessive spillage of combustion gases



Test natural draft furnace or water heater for spillage in excess of 2min



Test all sides of natural draft flues since draft may be uneven

### Tools:

1. Smoke pencil
2. Timer

## 2.0201.3b - Carbon Monoxide (CO) Test in Appliance Vent

### Desired Outcome:

Accurate information about appliance safe operation is gathered

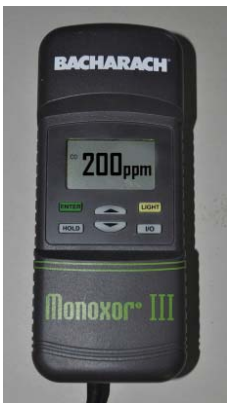
### Specification(s):

CO will be tested for in undiluted flue gases of combustion appliances in conditions with largest negative pressure as determined from Detail 2.0201.1e. If CO levels exceed 400 ppm air-free measurement in furnaces, service will be provided to reduce CO to below these levels (unless CO measurement is within manufacturer specifications)

If CO levels exceed 200 ppm air-free measurement in water heaters or room heaters, service will be provided to reduce CO to below these levels (unless CO measurement is within manufacturer specifications)

### Objective(s):

Measure CO and report excessive levels



#### Unsafe

CO Levels cannot exceed 200ppm as measured, unless to manufacturer specs

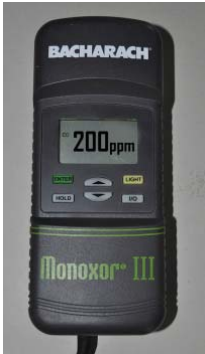


#### Best Practice

Test CO levels in undiluted flue gases and exhaust outlets, when accessible

### Tools:

1. Combustion analyzer with probe



CO levels cannot exceed 200ppm, or 400 ppm air-free CO



Test undiluted flue gases in induced-draft furnaces



Test undiluted flue gases in natural draft furnaces



Test undiluted flue gases in natural draft water heaters



Test accessible exhaust outlets for direct-vent appliances



Test accessible exhaust outlets for power-vented appliances

## 2.0201.3c - Final Test Out

**Desired Outcome:**

Accurate information about appliance safe operation is gathered

**Specification(s):**

**Final combustion testing will be conducted at project completion to ensure compliance with the above specifications**

**Objective(s):**

**Ensure safe operation of combustion appliance within the whole house system after any repair project**

## 2.0301.1b - Smoke Alarm (Battery Operated)

### Desired Outcome:

Properly installed smoke alarms

### Specification(s):

Battery operated alarms will be installed in accordance with the 2012 IRC and manufacturer specifications

### Objective(s):

Ensure proper installation



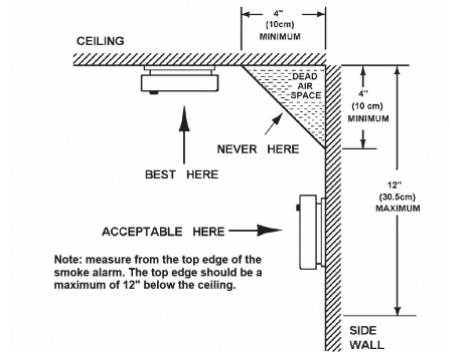
All homes should have UL-217 rated smoke alarms

Paraphrased from 2012 IRC R314: Smoke alarms will be permitted to be battery operated when installed in buildings without commercial power or when alterations or repairs do not result in the removal of interior wall or ceiling finishes exposing the structure to provide access for hard-wiring, unless there is an attic, crawl space, or basement available with could provide access.

## 2.0301.1b - Smoke Alarm (Battery Operated)



Smoke alarms can be battery-operated



Smoke alarms shall not be within 4" of a corner. If mounted on the wall, the alarm must be within 12" of the ceiling.

## 2.0301.2b - CO Detection and Warning Equipment (Battery Operated)

### Desired Outcome:

Properly installed CO alarms or monitors

### Specification(s):

Battery operated CO detection or warning equipment will be installed in accordance with ASHRAE 62.2 and manufacturer specifications as required by the authority having jurisdiction

### Objective(s):

Ensure proper installation



Houses should have carbon monoxide monitors installed near sleeping areas



Battery operated CO alarms should be UL-2075 or UL-2034 compliant

Reference 2012 IRC R315: An approved CO alarm will be installed outside of each separate sleeping area in the immediate vicinity of the bedrooms in dwelling units within which fuel-fired appliances are installed and in dwelling units that have attached garages. Single-station CO alarms will comply with UL 2034 and will be installed in accordance with this code and the manufacturer's installation instructions. Per WPN 14-01, full compliance with ASHRAE 62.2.2013 and NFPA 720 is required.

Labeling: Installer shall write the date installed or manufacturers recommended replacement date on the device label so it is visible without having to remove the device.

Carbon Monoxide (CO) Detectors: Local agencies shall install a minimum of one carbon monoxide (CO) detector per floor in every dwelling unit where detectors are not present or are inoperable. Replacement of operable CO detectors is not an allowable cost. CO detectors shall be installed in accordance with manufacturer's requirements. a. Detector standards: Detectors shall have:

- (1) A 5-year warranty for residential models or 1-year warranty for commercial low-level models.
- (2) An electrochemical sensor.

- (3) A digital display that indicates CO levels in Parts Per Million (ppm).
- (4) The capability to accurately detect and display low levels of carbon monoxide to 15 ppm.
- (5) A label to verify testing and listing to the UL 2034 Standard.

Exception: CO Detectors need not be UL listed if a low level detector is desired. To comply with this exception, these commercial low-level detectors must meet or exceed all of the following:

- (a) ACGIH and NIOSH Standards.

## 2.0601.1a - Knob and Tube Identification & Required Inspection

### Desired Outcome:

Live unsafe wiring identified and brought to local codes

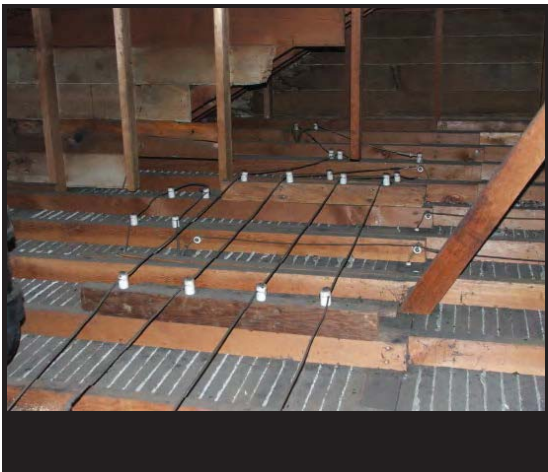
### Specification(s):

Contractor, assessor, auditor, or similar will inspect and assess the house to identify knob and tube wiring

### Objective(s):

Ensure occupant safety

Preserve the integrity and safety of the house



Knob & Tube wiring in an attic.

Knob & Tube wiring inspection form, to be completed by licensed electrician prior to insulating

### Tools:

1. AC Voltage Detector

Washington Variance allows knob and tube (K&T) wiring to be covered with insulation, but first requires a licensed electrician to inspect and certify in writing the knob and tube wiring system is safe for insulation contact.

## 2.0601.1a - Knob and Tube Identification & Required Inspection



1 First determine whether K&T wiring is active using an AC voltage detector. The tip glows red for active wiring.



2 Remember, K&T wiring can be beneath the floor and in wall cavities too.

KNOB AND TUBE  
ELECTRICAL SYSTEM INSPECTION FOR INSULATION

Client: \_\_\_\_\_  
 Location: \_\_\_\_\_  
 Field No.: \_\_\_\_\_  
 Work Order: \_\_\_\_\_  
 Order by Local Agency no: \_\_\_\_\_  
 Refer to WAC 260-65A-020 Knob and tube wiring

Type of wiring system: Panel \_\_\_\_\_ Fuse & Trip \_\_\_\_\_  
 ABE wires \_\_\_\_\_ APPROVED \_\_\_\_\_

1. General Condition: Acceptable \_\_\_\_\_ Unacceptable \_\_\_\_\_  
 2. Wire insulation: Acceptable \_\_\_\_\_ Unacceptable \_\_\_\_\_  
 3. Circuit condition: Acceptable \_\_\_\_\_ Overloaded \_\_\_\_\_  
 4. Phase wire correct: Yes \_\_\_\_\_ No \_\_\_\_\_  
 5. If open line: Shut-off \_\_\_\_\_  
 6. Neutral safety: \_\_\_\_\_

Under floor wiring: APPROVED \_\_\_\_\_

1. General Condition: Acceptable \_\_\_\_\_ Unacceptable \_\_\_\_\_  
 2. Wire insulation: Acceptable \_\_\_\_\_ Unacceptable \_\_\_\_\_  
 3. Circuit condition: Acceptable \_\_\_\_\_ Overloaded \_\_\_\_\_  
 4. Phase wire correct: Yes \_\_\_\_\_ No \_\_\_\_\_  
 5. If open line: Shut-off \_\_\_\_\_  
 6. Neutral safety: \_\_\_\_\_

Wall wiring: APPROVED \_\_\_\_\_

1. General Condition: Acceptable \_\_\_\_\_ Unacceptable \_\_\_\_\_  
 2. Wire insulation: Acceptable \_\_\_\_\_ Unacceptable \_\_\_\_\_  
 3. Circuit condition: Acceptable \_\_\_\_\_ Overloaded \_\_\_\_\_  
 4. Phase wire correct: Yes \_\_\_\_\_ No \_\_\_\_\_  
 5. If open line: Shut-off \_\_\_\_\_  
 6. List measured voltage drop readings for all receptacles on exterior walls. Start at first end, list clockwise \_\_\_\_\_

7. Remedial repairs: \_\_\_\_\_

We have observed the knob wiring as established as possible and assume no responsibility for any wiring system caused by the installation or the execution.

Inspector's Name: \_\_\_\_\_ Date of evaluation: \_\_\_\_\_  
 License No: \_\_\_\_\_ Firm: \_\_\_\_\_

3 If the K&T wiring is active, a licensed electrician must inspect the wiring and document the findings.

## 3.1001.1c - Sealant Selection

### Desired Outcome:

Penetrations and chases sealed to prevent air leakage and moisture movement between the attic and conditioned space

### Specification(s):

Sealants will be compatible with their intended surfaces

Sealants will allow for differential expansion and contraction between dissimilar materials

Sealants will be continuous and meet fire barrier specifications, according to authority having jurisdiction

### Objective(s):

Select permanent sealant

Ensure sealant meets or exceeds the performance characteristics of the surrounding materials



**Before**

Wiring penetration in wall top allows air leakage and moisture movement between unconditioned and conditioned space.



**After**

Air sealing prevents air leakage and moisture movement between unconditioned and conditioned space

### Tools:

1. Caulk gun
2. Foam gun

### Materials:

1. Caulk
2. One-part foam
3. Backing or infill

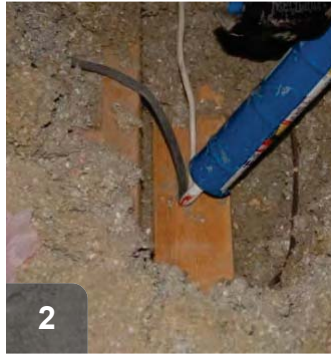
Seal around penetrations in the ceiling made by plumbing pipes and vent stacks, chimneys, ducting, ventilation equipment, electrical wiring, lighting fixtures and top plates to adjacent materials.

Cost effectiveness of sealing top plates along outside walls may prohibit this measure, due to difficult access. Document when such measures are not cost effective.

## 3.1001.1c - Sealant Selection



1 Locate wall tops in attic and look for plumbing and electrical penetrations.



2 Fill wall top penetrations with caulk or one-part foam.



3 Sealed wall top penetration.



4 Top plate sealed to ceiling material.

## 3.1001.1d - High Temperature Application: Attic Air Sealing

### Desired Outcome:

Penetrations and chases sealed to prevent air leakage and moisture movement between the attic and conditioned space

### Specification(s):

Only non-combustible sealant will be used in contact with chimneys, vents, and flues

Local codes will be referenced

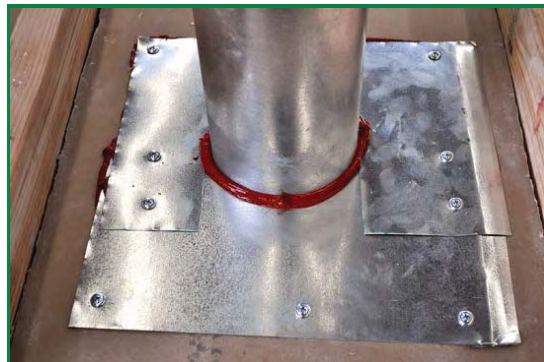
### Objective(s):

Prevent a fire hazard



 Before

Gaps around combustion exhaust flues need to be sealed



 After

Sealed penetrations and chases should utilize high-temperature materials

### Tools:

1. Drill/screwdriver
2. Caulk gun
3. Metal snips

### Materials:

1. High-temperature caulking, tested with accordance to ASTM E 136
2. Non-combustible damming material
3. Fasteners

Use appropriate gloves when working with sheet metal.

### 3.1001.1d - High Temperature Application: Attic Air Sealing



1 Prepare work area by removing any insulation and debris



2 Use high-temperature caulking (600F min), tested in accordance with ASTM E 136



Apply first ring of caulking to match shape of opening



4 Apply second ring of caulking to size and shape of rigid material



5 Fasten rigid, non-combustible material and apply additional caulking



6 Fasten rigid material to cover penetration and seal against flue with caulk

Clearance to Combustibles for Combustion Appliance Vents		
Fuel	Vent type	Minimum Clearance to combustibles
Gas, LP	Type B gas vent	1"
	Single wall metal	6"
Fuel Oil	Type L vent	9"
	Single wall metal	18"
Solid Fuel	Type L vent	9"
	Single wall metal	18"
7 Pe Jet fuel	Type L vent	per manufacturer's Specification

### 3.1001.2b - Standard Chase (Interior Walls Covered With Drywall or Plaster)

**Desired Outcome:**

Chase capped to prevent air leakage and moisture movement between the attic and conditioned space

**Specification(s):**

Entire opening will be spanned with rigid material

Material will be cut to fit and fastened as required

**Objective(s):**

Reduce opening to what can be sealed with sealant



Unsealed standard chases covered with drywall can be leakage points



The air barrier is maintained by capping chases with rigid material

**Tools:**

- 1. Drill/screwdriver
- 2. Caulk gun

**Materials:**

- 1. XPS
- 2. Drywall
- 3. Caulk
- 4. Sheet metal
- 5. OSB or plywood

### 3.1001.2b - Standard Chase (Interior Walls Covered With Drywall or Plaster)



Clear area of debris and insulation in preparation for work



Apply sealant all the way around opening



Trim rigid material, such as drywall or XPS, to size and place over sealant



Fasten rigid material appropriately, such as with screws

## 3.1001.2c - Non-Standard Chase (Interior Walls Covered With Wood or Paneling)

### Desired Outcome:

Chase capped to prevent air leakage and moisture movement between the attic and conditioned space

### Specification(s):

Material will be used that can be exposed to the interior of the house and meet the flame and smoke spread indexes as required in 2012 IRC R302.9

### Objective(s):

Prevent a fire hazard



Paneled drop soffits typically are more combustible than plain drywall



When sealing on attic side use 5/8 inch drywall, fasteners and sealant

### Tools:

1. Drywall saw
2. Tape measure
3. Caulk gun
4. Drill

### Materials:

1. Drywall
2. Fire-block sealant
3. Fasteners

EPS or bead-board are not acceptable materials.

## 3.1001.2c - Non-Standard Chase (Interior Walls Covered With Wood or Paneling)



Soffit open to attic



Soffit now properly sealed from attic with drywall, sealant and fasteners

## 3.1001.2d - Support - Capping Chases Greater Than 24"

### Desired Outcome:

Chase capped to prevent air leakage and moisture movement between the attic and conditioned space

### Specification(s):

Support material will be installed for spans wider than 24", except when air barrier material is rated to span greater distance under load (e.g., wind, insulation)

### Objective(s):

Ensure seal stays in place and does not sag



Spans greater than 24 inches require additional bracing before capping



Support should prevent cap from sagging or moving

### Tools:

1. Drill
2. Saw
3. Tape measure

### Materials:

1. Lumber
2. Drywall
3. Fasteners

### 3.1001.2d - Support - Capping Chases Greater Than 24"



Create bracing to support spans larger than 24", either from above or below



When supporting from above, apply adhesive between drywall and bracing



Bracing can be screwed to drywall before capping chase



Ensure new bracing is secure by using screws to fasten to joist



Once chase is capped, it is now ready to be sealed along framing

## 3.1001.2e - Joint seal

### Desired Outcome:

Chase capped to prevent air leakage and moisture movement between the attic and conditioned space

### Specification(s):

Continuous seal will be installed around seams, cracks, joints, edges, penetrations, and connections

### Objective(s):

Provide airtight, durable seal that does not move, bend, or sag



 Before

Chases need to be capped and sealed to prevent leakage



 After

Chase is sealed along all cracks, gaps, and penetrations

### Tools:

1. Spray foam gun
2. Caulk gun
3. Screw gun

### Materials:

1. Spray foam
2. Caulk
3. Drywall

Always wear protective gloves, eye protection and respirator when working with insulation and sealants.



Chase has been capped but needs to be sealed



Sealant is used to fill in all cracks and gaps along edges of chase cap. Cap is now sealed.

## 3.1001.3b - Sealing Methods - Open Wall Top

### Desired Outcome:

Continuous air barrier prevents air leakage and moisture movement between the attic and conditioned space

### Specification(s):

Entire opening will be spanned with rigid material in line with the ceiling level

Material will be cut to fit and fastened as required

OR

Wall below openings will be dense packed

OR

Wall below openings will be bridged and sealed with spray polyurethane foam (SPF)

Sealants will be used that prevent visible air movement using chemical smoke at 50 pascals of pressure difference

### Objective(s):

Prevent air leakage from wall cavity to attic



Wall cavities are open to attic



Whatever option chosen, test for visible air movement with chemical smoke at 50 pascals of pressure difference

**Tools:**

1. Utility knife
2. Saw
3. Insulation machine
4. Caulk gun
5. Spray foam gun

**Materials:**

1. Drywall
2. XPS
3. Spray foam
4. Caulk
5. Fasteners
6. Dense packable insulation
7. Lumber

REMEMBER: gaps larger than 24" require support for some air sealing materials. See Field Guide spec 3.1001.2d.

### 3.1001.3b - Sealing Methods - Open Wall Top



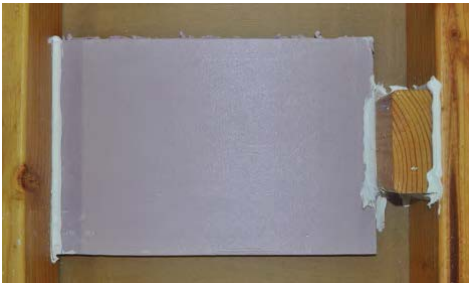
Option 1: Dense pack cavities through wood cap fastened in place



Option 2: Bridge cavities with spray foam



Option 3, Step 1: Apply sealant around opening and on surrounding framing



Option 3, Step 2, Option A: Cap with XPS and seal exposed joints



Option 3, Step 2, Option B: Cap with drywall and seal exposed joints



REMEMBER: gaps larger than 24" require support for some air sealing materials. See Field Guide spec 3.1001.2d.

## 3.1001.3e - Adjacent Framing - Open Wall Top

### Desired Outcome:

Continuous air barrier prevents air leakage and moisture movement between the attic and conditioned space

### Specification(s):

All remaining gaps at the top of the opening will be sealed

OR

All remaining gaps at the top of the chase will be sealed

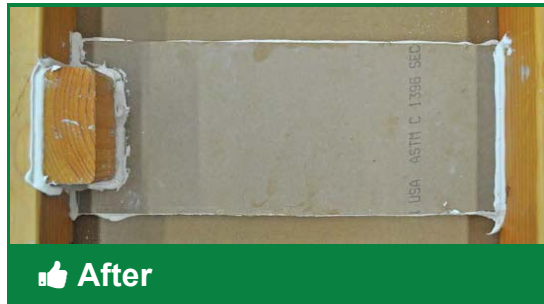
### Objective(s):

Ensure airtight seal from one finished side of the wall assembly to the other



**Before**

Balloon framing needs to be capped and sealed to prevent leakage



**After**

All edges of the cap should be sealed to surrounding surfaces, including adjacent framing

### Tools:

1. Spray foam gun
2. Caulk gun

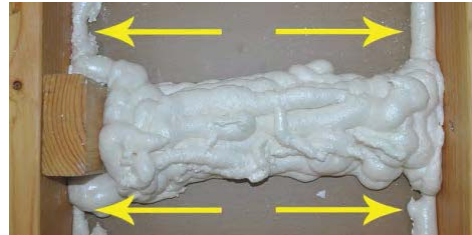
### Materials:

1. Spray foam (SPF)
2. Caulk

### 3.1001.3e - Adjacent Framing - Open Wall Top



For rigid material applications, sealant should be applied to framing



When using SPF to bridge cavity, extend SPF along joist and adjacent framing

## 3.1003.1b - Sealing Methods - Drop Ceiling

### Desired Outcome:

Continuous air barrier prevents air leakage and moisture movement between the attic and conditioned space

### Specification(s):

Entire opening will be spanned with rigid material in line with the ceiling level

Material will be cut to fit and fastened as required

OR

Side of stud bays will be sealed with rigid material from bottom of dropped ceiling to top-plate

OR

Wall below openings will be dense packed

OR

Wall below openings will be bridged and sealed with SPF

Seals will be used that prevent visible air movement using chemical smoke at 50 pascals of pressure difference

### Objective(s):

Prevent air leakage from dropped ceiling to attic



**Before**

Damage to an older ceiling reveals the new ceiling below



**After**

Rigid material sealed in place creates an air barrier

**Tools:**

1. Utility knife
2. Saw
3. Drill
4. Insulation machine
5. Caulk gun
6. Spray foam gun
7. Tape measure

**Materials:**

1. Caulk sealant
2. Rigid material -- XPS or Drywall
3. Spray foam
4. Fasteners
5. Dense packable insulation
6. Wrapped fiberglass batts

### 3.1003.1b - Sealing Methods - Drop Ceiling



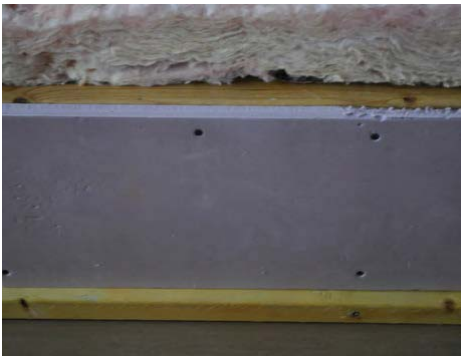
Prepare work area by removing existing insulation and debris



Option 1, Step 1: Run a bead of sealant around damage in old ceiling



Option 1, Step 2: Cover openings with rigid material, either XPS or drywall



Option 2: Seal with rigid material along face of stud cavities



Option 3: Dense pack cavities through fastened wood plate



Option 4: Bridge cavities at new ceiling level with wrapped batts and SPF



Whatever option chosen, test with chemical smoke at 50 pascals of pressure difference to verify no leakage

## 3.1003.3b - Above Closets and Tubs

### Desired Outcome:

Continuous air barrier prevents air leakage and moisture movement between the attic and conditioned space

### Specification(s):

Entire opening will be spanned with rigid material in line with the ceiling level

Material will be cut to fit and fastened as required

OR

Side of stud bays will be sealed with rigid material from bottom of dropped ceiling to top-plate

OR

Wall below openings will be dense packed

OR

Wall below openings will be bridged and sealed with SPF

Seals will be used that prevent visible air movement using chemical smoke at 50 pascals of pressure difference

### Objective(s):

Prevent air leakage from dropped ceiling to attic



Unsealed drop soffits over tubs and closets can be a point of leakage



Capped soffits minimize leakage to and from unconditioned spaces

**Tools:**

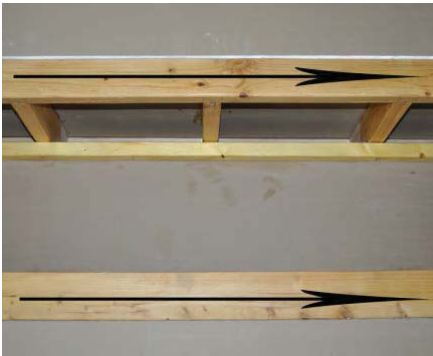
1. Utility knife
2. Saw
3. Tape measure
4. Insulation machine
5. Drill
6. Caulk gun
7. Spray foam gun
8. Smoke pencil

**Materials:**

1. XPS
2. Drywall
3. Plywood
4. Caulk
5. Spray foam
6. Dense packable insulation
7. Fasteners
8. Wrapped fiberglass batts

Support material will be installed for spans wider than 24", except when air barrier material is rated to span greater distance under load (e.g., wind, insulation)

### 3.1003.3b - Above Closets and Tubs



Option 1, Step 1: Apply sealant to top plates or other relevant surfaces



Option 1, Step 2: Cover soffit with rigid material, such as drywall



Option 1, Step 3: Secure the rigid material with screws



Option 2: Cover face of stud bay with rigid material, like XPS or plywood



Option 3: Dense pack cavity through fastened wood cap



Option 4: Bridge stud bay with wrapped fiberglass and spray foam



All Options: Test with chemical smoke at 50 pascals of pressure difference to verify no air movement

## 3.1003.3e - Adjacent Framing - Above Closets and Tubs

### Desired Outcome:

Continuous air barrier prevents air leakage and moisture movement between the attic and conditioned space

### Specification(s):

All remaining gaps at the top of the dropped ceiling will be sealed

### Objective(s):

Provide airtight framing from one finished side of the dropped ceiling to the other



Dropped soffits need to be capped and sealed to prevent leakage



No gaps should remain after sealant is applied along adjacent framing

### Tools:

1. Caulk gun
2. Spray foam gun

### Materials:

1. Caulk sealant
2. Spray foam

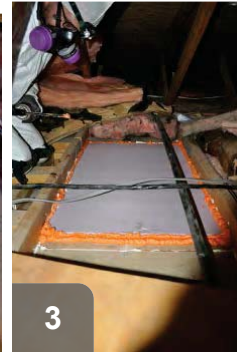
## 3.1003.3e - Adjacent Framing - Above Closets and Tubs



1  
Apply sealant to surrounding surfaces before setting cap in place



2  
Sealant should extend along adjacent framing and into seams at top plates



3  
Additional sealant should fill in all remaining gaps after cap has been set

## 3.1003.6b - Soffit General

### Desired Outcome:

Dropped soffits sealed to prevent air leakage and moisture movement between the attic and conditioned space

### Specification(s):

Air flow will be blocked at soffit in locations where access allows

### Objective(s):

Provide continuous air barrier across soffit openings



 Before

Accessible drop soffits should be sealed to prevent heat gain/loss



 After

Completely sealed drop soffits and chases minimize heat transfer

### Tools:

1. Measuring tape
2. Utility knife
3. Caulk gun
4. Spray foam gun
5. Saw
6. Drill

### Materials:

1. Caulk
2. Spray foam
3. Lumber
4. XPS
5. Fasteners

There are a variety of ways to seal soffits. Please examine 3.1003.6c and 3.1003.6d for more information.

## 3.1003.6c - Option 1: Bring Soffit Inside (Seal at Top)

### Desired Outcome:

Dropped soffits sealed to prevent air leakage and moisture movement between the attic and conditioned space

### Specification(s):

Entire opening will be spanned with rigid material in line with the ceiling level

Material will be cut to fit and fastened as required

### Objective(s):

Prevent air leakage from wall to attic

Reduce opening to what can be sealed with sealant

Ensure closure is permanent and supports any load (e.g., wind, insulation)

Bring soffit into thermal boundary



Standard soffits are often open to the attic and uninsulated



Rigid material encloses the soffit into the conditioned living space

### Tools:

1. Drill/screwdriver
2. Caulk gun

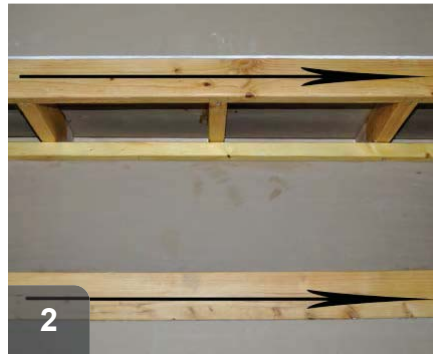
### Materials:

1. Drywall
2. Sealant

### 3.1003.6c - Option 1: Bring Soffit Inside (Seal at Top)



Soffits open to the attic need to be sealed to maintain air barrier



Apply sealant along top plates



Cap soffit with rigid material, such as drywall, cut to size



Fasten cap with screws to set sealant and create air barrier



Insulate over now-capped soffit

## 3.1003.6d - Option 2: Leave Soffit Outside (Seal at Bottom or Side)

### Desired Outcome:

Dropped soffits sealed to prevent air leakage and moisture movement between the attic and conditioned space

### Specification(s):

Each stud bay will be spanned with rigid material will be cut to fit and fastened as required

OR

Backing at each stud bay will be provided and will be sealed

OR

Side of stud bays will be sealed with rigid material from bottom of soffit to top-plate

OR

A sealed rigid barrier will be installed at all transitions

### Objective(s):

Prevent air leakage from wall to soffit

Reduce opening to what can be sealed with sealant

Ensure soffit is outside of the thermal boundary



 Before

Wall cavities are open to attic and heat transfer due to dropped soffit



 After

Wall cavities capped and air-sealed in one of a variety of options

**Tools:**

1. Tape measure
2. Utility knife
3. Saw
4. Insulation machine
5. Drill
6. Caulk gun
7. Spray foam gun

**Materials:**

1. XPS
2. Drywall
3. Plywood
4. Lumber
5. Fasteners
6. Caulk
7. Spray foam
8. Dense packable insulation
9. Poly-wrapped insulation

## 3.1003.6d - Option 2: Leave Soffit Outside (Seal at Bottom or Side)



Clear work area of insulation and debris



Option 1: Span each stud bay with rigid material at level of soffit



Option 2: Backing used to fill bays and sealed with spray foam



Option 3: Stud bay will faced with rigid material, fastened and sealed

## 4.1001.1a - Air Barrier System - Non-IC Rated Recessed Light

### Desired Outcome:

Ensure safety from fire and prevent air leakage

### Specification(s):

The non-IC rated light fixture will be replaced with an airtight and IC- rated fixture

OR

A fire-rated air barrier system (i.e., equivalent to 5/8 fire code gypsum wallboard) will be used to separate non-IC rated recessed lights from insulation, using one of the methods below:  
A fire-rated airtight closure taller than surrounding attic insulation will be placed over non-IC rated recessed lights

OR

The fixture(s) may be replaced with surface mounted fixture and opening sealed

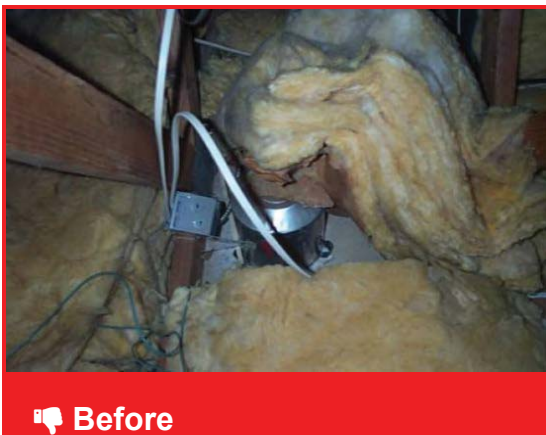
OR

Air sealing measures as approved by the authority having jurisdiction

### Objective(s):

Prevent a fire hazard

Prevent air leakage through fixture



Non-IC rated recessed light fixtures should be dammed from insulation



Sealed box around non-IC light should be taller than surrounding insulation

**Tools:**

1. Utility knife
2. Tape measure
3. Screw gun
4. Sheet rock saw

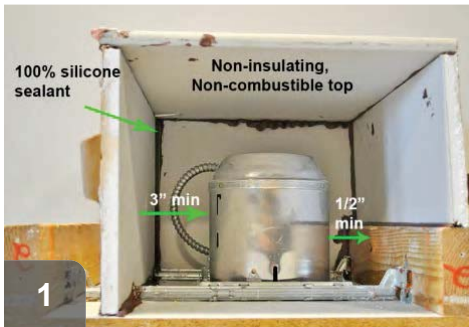
**Materials:**

1. 5/8" sheet rock or equivalent
2. Mastic, foam or caulk sealant
3. Screws

Note: 3" clearance between enclosure and fixture. Enclosure height shall be above surrounding insulation. Top of enclosure shall not be insulated. Enclosure lid may not exceed R value of .5. if this spec cannot be met, replace Non IC rated fixture with Airtight IC-rated fixture or surface-mounted fixture.

Recessed fixtures must meet air barrier test at 50 pascal pressure difference with no smoke movement, or measure less than one pascal using a pressure pan.

## 4.1001.1a - Air Barrier System - Non-IC Rated Recessed Light



Box should be constructed with clearances in mind



Sealed box should be constructed of fire-rated drywall



OR non-IC can light can be replaced with IC-rated recessed light

# Air Barrier System - IC Rated Recessed Light

## Specification(s):

Use air sealing measures as approved by the authority having jurisdiction with the purpose of reducing air flow from conditioned space into unconditioned space. Recessed fixtures must meet air barrier test at 50 pascal pressure difference with no smoke movement, or measure less than one pascal using a pressure pan.

## Notes:

A fire-rated air barrier system (i.e., equivalent to 5/8 fire code gypsum wallboard) will be used when constructing covers over the tops of IC Rated recessed fixtures. Covers over the tops of IC Rated recessed fixtures must be a Class 1 material, according to ASTM E84 (flame spread not to exceed 25, smoke index not to exceed 450). When applying sealant directly to IC rated recessed fixture, and sealant will be covered with insulation, ASTM 136 Fire Rated sealant must be used.



IC rated recessed fixtures might have air leakage at two locations: between the can and the ceiling material, and between the inner and outer “cans” of the fixture.



Use latex caulk to air seal gaps from the interior of the home.

# Air Barrier System - IC Rated Recessed Light



IC rated recessed fixture air sealed from the interior of the home.



IC rated recessed fixtures can also be sealed from the attic when accessible.



IC rated recessed fixtures can be sealed with fire-rated box assemblies.



When applying sealant directly to IC rated recessed fixtures, the sealant must meet ASTM136 fire rating.

## 4.1001.3 - Air Seal and Dam Around Hot Pipe

### Desired Outcome:

Combustible materials kept away from combustion sources

### Specification(s):

Holes, penetrations, and bypasses will be sealed

Dams will be fixed in places that maintain required clearance

### Objective(s):

Prevent air leakage

Ensure insulation dams maintain clearance



**Before**

Insulation is combustible and does not meet clearance requirements from flue.



**After**

Damming around flue maintains 3" clearance from hot surface and shall extend above final insulation level.

### Tools:

1. PPE: gloves, protective eyewear
2. Metal snips
3. Caulk gun
4. Fasteners

### Materials:

1. Aluminum coil stock
2. High temperature caulk with ASTM E136 listing
3. Caulk
4. Backer rod
5. Spray foam
6. Rigid non-combustible material for damming

1. Air seal chimney penetration prior to damming.
2. Construct and install a rigid dam to ensure a 3" clearance between the dam material and the combustion flue or chimney.
3. Fasten damming to substrate or framing to prevent it from moving.
4. Damming shall extend higher than the top of the insulation to be installed.

5. Ensure the dam material does not bend, move, or sag.

## 4.1001.3a - Air Seal and Dam Around Hot Pipe



Gaps around flues and penetrations need to be sealed before insulating



Rigid, non-combustible material should be used to construct seals and dams on flues



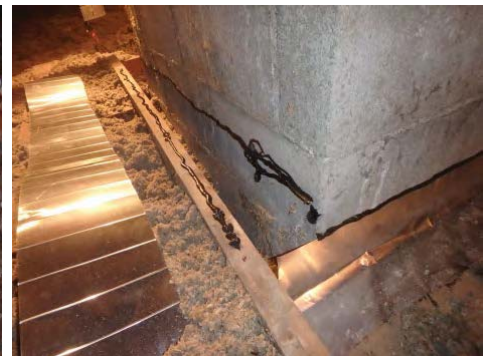
Only construct dam after sealing has been completed properly



Damming is held in place with mechanical fasteners and maintains 3" clearance from flue.



Air leak around masonry chimney, needs to be air sealed.



Rigid, non-combustible material should be used to construct seals and dams on chimneys



Only construct dam after sealing has been completed properly.



Damming is held in place with mechanical fasteners and maintains 3" clearance from chimney.

Clearance to Combustibles for Combustion Appliance Vents		
Fuel	Vent type	Minimum Clearance to combustibles
Gas, LP	Type B gas vent	1"
	Single wall metal	6"
Fuel Oil	Type L vent	9"
	Single wall metal	18"
Solid Fuel	Type L vent	9"
	Single wall metal	18"
Pellet fuel	Type L vent	per manufacturer's Specification

All combustion appliance venting and flues must maintain clearance to combustibles.

## 4.1001.4a - Installation

### Desired Outcome:

Attic ventilation meets code requirements and insulation is protected from wind washing

### Specification(s):

If soffit venting or eave venting is present, baffles will be mechanically fastened to block wind entry into insulation or to prevent insulation from blowing back into the attic

If soffit venting or eave venting is present, baffles will be installed to maintain clearance between the roof deck and baffle in accordance with manufacturer specifications

Installation will allow for the highest possible R-value above the top plate of the exterior wall

### Objective(s):

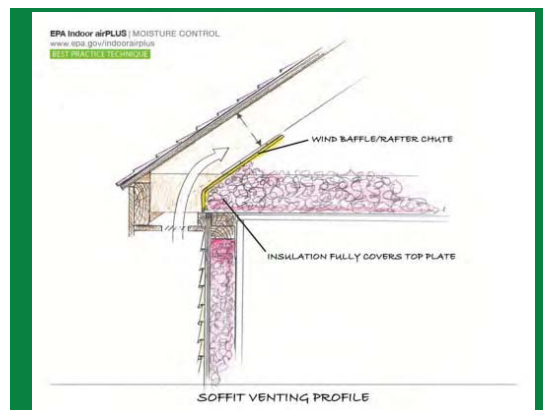
Ensure insulation R-value is not reduced

Maintain attic ventilation



Before

Insulation should not block vented eaves



After

### Tools:

1. Stapler

### Materials:

1. Baffles
2. Staples

Low attic-vent baffles shall extend vertically a minimum of 4" above the final level of the insulation. Mechanical fasteners shall permanently affix baffle in place.

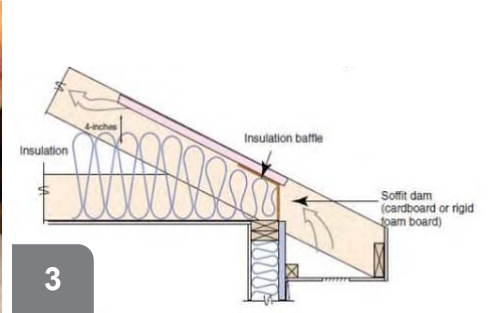
## 4.1001.4a - Installation



Low attic-vent baffles should be securely fastened to prevent movement over time



Allow a standard one-inch gap for air flow between baffle and underside of roof



Low attic-vent baffles shall be placed to allow insulation over top plate and prevent insulation from falling into eave

## 4.1004.2a - Knee Wall Prep for Batt

### Desired Outcome:

Airtight cavity and properly insulated knee wall

### Specification(s):

All knee walls will have a top and bottom plate or blockers installed using a rigid material

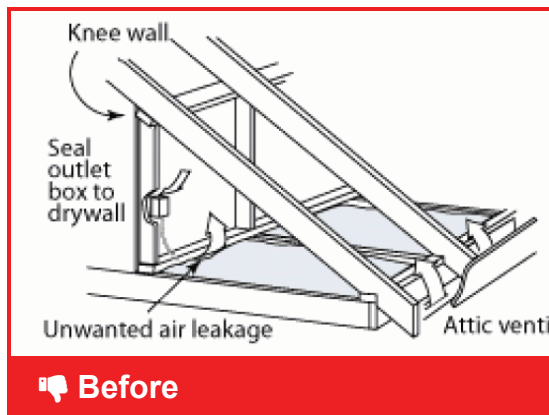
All joints, cracks, and penetrations will be sealed in finished material, including interior surface to framing connections

### Objective(s):

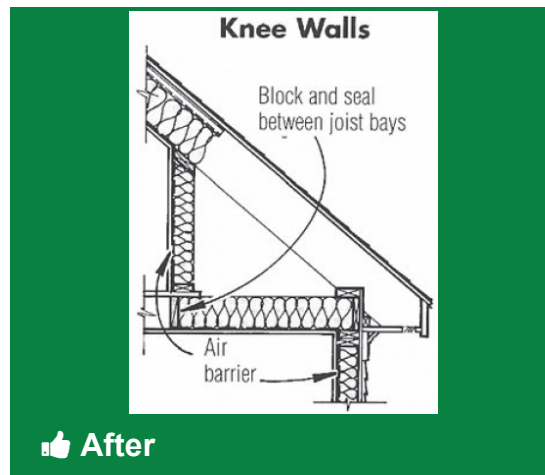
Eliminate bending, sagging, or movement that may result in air leakage

Prevent air leakage through the top or bottom of the knee wall

Create an air barrier



Unsealed joist cavity below knee wall



Sealed joist cavity below knee wall

### Tools:

1. Spray foam gun
2. Caulk gun
3. Tape measure
4. Utility knife
5. Drill
6. Saw

### Materials:

1. XPS
2. OSB, plywood, drywall,
3. Caulk
4. Spray foam
5. Fasteners

## 4.1004.2a - Knee Wall Prep for Batts



1 Measure floor joist opening so material can be cut and installed to prevent air leakage.



2 Install blocking to prevent air leakage.



3 Blocking material is sealed to surrounding joist and framing

## 4.1004.2b - Knee Wall - Installation

### Desired Outcome:

Airtight cavity and properly insulated knee wall

### Specification(s):

Insulation will be installed using one of the following methods:

- New batts will be installed in accordance with manufacture specifications
- All existing batted insulation will be adjusted to ensure it is in full contact with the interior cladding and the top and bottom plates

### Objective(s):

Eliminate misalignment of existing insulation



**Before**  
Knee wall with batts improperly installed and missing from stud bays



**After**  
Properly fit insulation filling full volume of stud bay

### Tools:

1. Utility knife
2. Tape measure

### Materials:

1. Fiberglass batts

NOTE: Required twine or lath support for knee wall insulation is same as that for floor insulation. See insulation support matrix below. Also, if knee wall area is used for storage fiberglass shall be covered with weather resistant barrier (WRB) or FSK to prevent human contact with fiberglass.

## 4.1004.2b - Knee Wall - Installation



1 Where existing insulation is improperly installed, fix it



2 Kraft-face should go to "warm in winter" side and batt should fill bay



3 Batts should fill entire volume of knee wall stud bays



4 Knee wall insulation is supported by nylon, stapled in a zig zag pattern, 12" on center.

FLOOR SUPPORT MATRIX						
Floor Type	Support Material	Material requirements	Maximum Spacing	Acceptable patterns	Minimum fastener type	Minimum fastener depth
Joist up to 24"	Lath	3/4X1/2"	24" O.C.	Across floor joist	Corrosion resistant 3/8" crown 18AWG	5/8"
Joist up to 24"	Terra	150 LBS, polyester, polypropylene or nylon	12" O.C.	Stapled in Zigzag (must be stapled at each joist)	Corrosion resistant 3/8" crown 18AWG	4/8"
Post & Beams over 12" O.C.	Lath	3/4X1/2"	24" O.C.	Across floor beams up to 54". If over 54" need center support	Corrosion resistant 3/8" crown 18AWG	5/8"
Post & Beams over 12" O.C.	Terra	150 LBS, polyester, polypropylene or nylon	12"	Stapled up to 54" across. If over 54" need center support	Corrosion resistant 3/8" crown 18AWG	5/8"

5 Required twine or lath support for knee wall insulation is same as that for floor insulation.

## 4.1005.2a - Accessible Floors - Loose-Fill Installation - Preparation

### Desired Outcome:

Consistent, uniform thermal boundary between conditioned and unconditioned space controls the heat flow

### Specification(s):

Subfloor or drywall will be removed to access cavities as necessary, including inaccessible knee-wall attic floor spaces

Insulation will be adequately marked for depth a minimum of every 300 square feet of attic area, with measurement beginning at the air barrier

All electrical boxes will be flagged to be seen above the level of the insulation

Open electrical junctions will have covers installed

Insulation dams and enclosures will be installed as required

### Objective(s):

Access the workspace

Verify uniformity of insulation material

Provide location of electrical boxes for future servicing

Prevent an electrical hazard



 **Before**

Accessible attic floors should be air sealed and insulated



 **After**

Depth markers and insulation dams aid in proper insulation of attic spaces

**Tools:**

1. Pry bar
2. Hammer
3. Caulk gun
4. Utility knife
5. Staple gun
6. Spray foam gun
7. Tape measure

**Materials:**

1. Flags
2. Depth markers
3. Staples
4. XPS
5. Caulk
6. Spray foam

## 4.1005.2a - Accessible Floors - Loose Fill Installation - Preparation



Check cavity for electrical junctions and penetrations



Flag and install covers on electrical junctions



Seal any penetrations



Non-IC (insulation contact) can lights should be covered with a dam and have no insulation on top



Install depth markers and insulation dams above height of insulation

## 4.1005.2c - Accessible Floor - Loose Fill Installation - Installation

### Desired Outcome:

Consistent, uniform thermal boundary between conditioned and unconditioned space controls the heat flow

### Specification(s):

All insulation will be installed to the depth indicated on the manufacturer coverage chart for desired R-value

### Objective(s):

Reduce heating and air conditioning costs

Improve comfort

Minimize noise



Insufficient level of insulation allows heat loss and wasted energy.



Attic floor blown with loose fill, achieving R-value of program requirements.

### Tools:

1. Insulation machine
2. Rake or stick to level insulation as needed

### Materials:

1. Loose fill insulation
2. paper rulers to mark insulation depth
3. Insulation manufacturer's coverage chart

NOTE: All insulation will be installed to the minimum unsettled depth and the maximum coverage per bag to reach a consistent depth for desired R-value indicated on the manufacturer's coverage chart.

# 4.1005.2c - Accessible Floors - Loose Fill Installation - Installation



1 Adjust machine settings for loose fill: open gate for high material flow, allow enough air pressure to avoid clogging.



2 Use depth markers to ensure insulation has reached prescribed R-value



3 PPE for attic includes N-95 respirator or greater, gloves, and coveralls.



4 Where flooring cannot be removed, verify insulation is meeting R-value goal

**R13 to R60**

**Nature Blend® Loose Fill Formula**

Coverage Chart for Thermal Acoustical Application

R Value @ 1" T	R Value @ 1" T	No. Acres (100' x 100' sq. ft.) per acre				2" x 4" @ 10" O.C.			
		Depth Per 100 Sq. Ft.	Vol. Per 100 Sq. Ft.	Weight Per 100 Sq. Ft.	Weight Per Cu. Yd.	Depth Per 100 Sq. Ft.	Vol. Per 100 Sq. Ft.	Weight Per 100 Sq. Ft.	Weight Per Cu. Yd.
13	4.4	4.8	17.4	87.5	0.28	15.8	63.5	0.36	
19	6.1	6.5	27.9	139.8	0.61	26.3	101.6	0.58	
22	6.9	6.2	33.2	161.1	0.73	30.5	120.8	0.67	
28	7.8	7.9	38.5	182.5	0.86	35.6	140.9	0.79	
30	9.2	8.3	47.6	219.0	1.05	44.8	172.4	0.98	
36	11.4	10.3	62.8	283.1	1.38	68.9	271.0	1.30	
49	14.6	15.1	82.0	322.2	1.80	75.7	302.7	1.73	
60	17.7	15.9	101.9	408.0	2.24	94.6	361.1	2.17	

5 Use the manufacturer's coverage chart to ensure R-value and post the chart with the insulation certificate

## 4.1006.1a - Pull-Down Attic Stair - Installation

### Desired Outcome:

Pull-down attic stair properly sealed and insulated

### Specification(s):

Hatches will be insulated to the maximum R-value structurally allowable up to the R-value of the adjoining insulated assembly

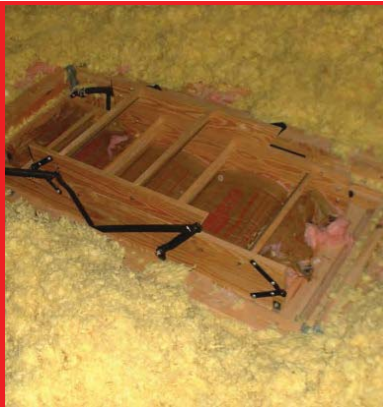
Pull-down stair rough opening will be surrounded with a durable dam that is higher than the level of the attic floor insulation

Counter-weights should be considered to ease accessibility for excessively heavy hatches

### Objective(s):

Achieve uniform R-value

Prevent loose insulation from entering the living area



 Before

Insulation needs to be dammed to keep from falling through during operation



 After

Insulated pull-down stairs cover installed to prevent air leakage

### Tools:

1. Tape measure, saw, drill
2. Caulk/ foam gun
3. Insulation machine and loose fill gear

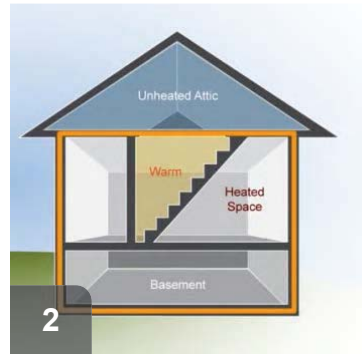
### Materials:

1. Caulk/ foam sealant
2. Lumber
3. Insulation: rigid XPS, or loosefill
4. Pre-fabricated stairwell cover, if applicable

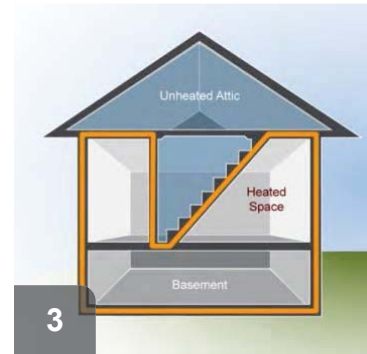
## 4.1006.1a - Pull-Down Attic Stair - Installation



Stairs and hatch should both be insulated to match r-value of attic



Attic stairwell, Option One: Establish pressure and thermal boundary consistent with attic floor.



Attic stairwell, Option Two: insulate stairwell walls and beneath stair treads, insulate and air seal stairwell door.

## 4.1006.2a - Attic Access Door - Installation

### Desired Outcome:

Attic access door properly sealed and insulated

### Specification(s):

Hatches will be insulated to the maximum R-value structurally allowable up to the R-value of the adjoining insulation assembly

Attic hatches rough opening will be surrounded with a durable, rigid protective baffle that is higher than the level of the surrounding attic floor insulation

### Objective(s):

Achieve uniform R-value on the attic door or hatch

Achieve uniform R-value on the attic floor

Prevent loose attic floor insulation from entering the living area



Uninsulated attic hatch



Hatch cover or panel access door should match r-value of attic insulation

### Materials:

1. Baffle or damming around horizontal access: 1/2" plywood or OSB.
2. Fiberglass batt or rigid foam to achieve R-value on hatch.
3. Strapping to attach fiberglass batt to access hatch.
4. Adhesive or fasteners to attach rigid foam to access hatch.

## 4.1006.2a - Attic Access Door - Installation



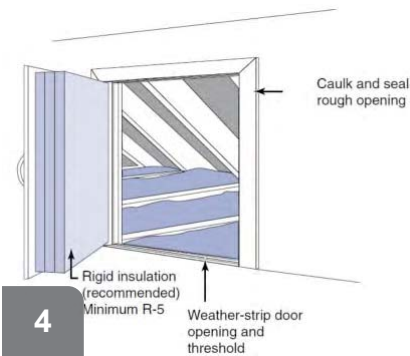
Create hatch cover that matches R-value of surrounding insulation



Build dam to hold back attic insulation and hold cover in place tightly



Hatch shall be tight fitting. Install weather strip if needed.



Alternate installation for vertical access panel to attic

# 4.1005.2d, 4.1301.1d, 4.1103.1b - Onsite Documentation

## Desired Outcome:

Consistent, uniform thermal boundary between conditioned and unconditioned space controls the heat flow

## Specification(s):

A dated receipt signed by the installer will be provided that includes:

- Insulation type
- Coverage area
- R-value
- Installed thickness and settled thickness
- Number of bags installed in accordance with manufacturer specifications

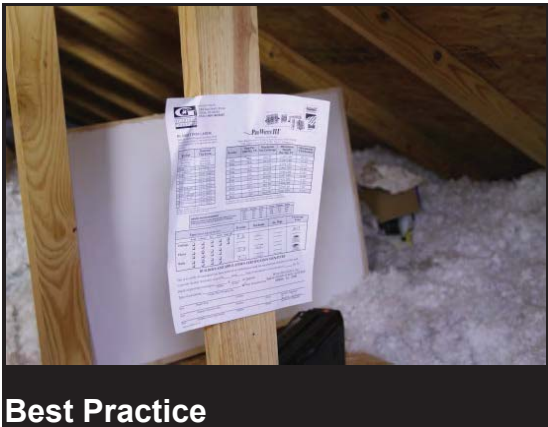
## Objective(s):

Document job completion to contract specifications

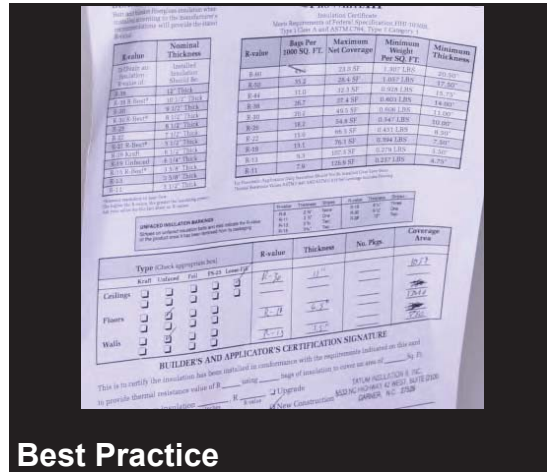
Confirm amount of insulation installed

Ensure ability to match bags required for total area completed

Comply with 16 CFR 460.17



**Best Practice**



**Best Practice**

Posted info includes insulation type, R-value, depth, coverage area, etc.

This requirement applies whenever insulation is installed.

Reference 16 CFR 460.17: The installer, must provide the customer or client documentation regarding the insulation installed. Documentation will indicate the coverage area, thickness, and

R-value of the insulation. The insulation certification must be dated and signed by the installer. Insulation certificate to be posted at entrance to attic or crawlspace and a copy shall be provided for project file.

To figure out the R-value of the insulation, use the data that the manufacturer gives you.

## 2.0111.3a - Debris Removal

### Desired Outcome:

Clean, safe, and easily accessible crawl space created

### Specification(s):

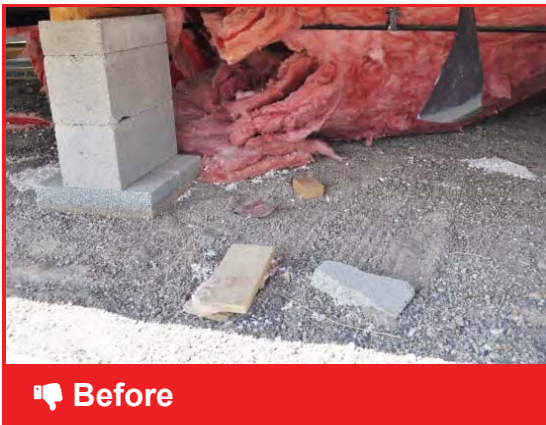
Under-floor grade will be removed of all vegetation and organic material

Debris that can cause injury or puncture ground covers (e.g., nails, glass, sheet metal screws, etc.) will be removed from the crawl space

### Objective(s):

Minimize punctures in ground liner

Minimize habitat for pests (Integrated Pest Management—IPM) and contaminant sources



Crawl spaces with trash and overgrowth need to be made clean and safe.



Clear away trash, wood debris and overgrowth. Remove anything that could puncture the ground cover.

### Tools:

1. PPE

Note: axles, tires can be left in place

## 2.0403.1b - Coverage - Ground Moisture Barrier

### Desired Outcome:

Durable, effective ground moisture barrier provides long-lasting access and minimizes ground vapor

### Specification(s):

A ground moisture barrier that covers 100% of the exposed crawl space floor will be installed

### Objective(s):

Reduce ground moisture entering the crawl space



 Before

Uncovered crawl space floors can cause moisture damage



 After

Ground moisture barrier to cover 100% of floor is installed last

### Materials:

1. Polyethylene plastic, white or black minimum 6 mil
2. Materials to secure poly: landscape staples, landscape blocks

Note: Reference SWS 2.0403.1a-e and SWS 2.0111.3a debris removal

Crawlspace shall be cleared of all wood debris or vegetation and anything likely to puncture the poly once it is in place.

- Poly shall cover 100% of bare ground,
- All seams shall overlap a minimum of 12 inches.
- Poly shall not be in direct contact with wood posts or framing.
- Where necessary, poly shall be fastened in place using landscape staples, spikes with washers or ballast to prevent shifting caused by routine access or other factors such as sloping grade or wind.

## 2.0701.2b - Sign Content - Crawlspace Maintenance

### Desired Outcome:

Posted signs inside of the crawl space provide essential safety and maintenance information to occupant and users of the crawl space

### Specification(s):

Those entering the crawl space will be cautioned not to damage the air barrier, ground moisture barrier, insulation, and mechanical components specific to the crawl space type

Anyone entering the crawl space will be alerted that immediate repairs are needed in case of damage

Installer contact information will be included on the sign in case there are questions or needs for repairs

### Objective(s):

Prevent damage to the crawl space after upgrade

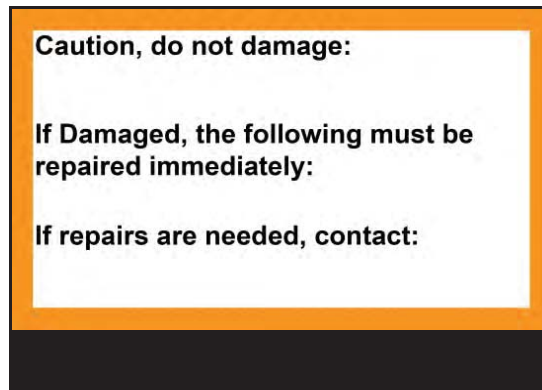
Educate anyone entering the crawl space

Provide occupants with a way to contact the installer



### Best Practice

Mount sign where clearly visible to anyone entering crawl space



Be sure sign includes relevant information to aid occupant in repairs

### Tools:

1. Printer
2. Staple gun

### Materials:

1. Paper
2. Laminant
3. Staples

Note: SWS 2.0701.2a-c requires a sign (min.8.5"x11") at entrance of crawlspace that states:

- 1) Ground cover, air barrier and insulation if disturbed shall be repaired and maintained.
- 2) Hazardous or flammable materials or liquids shall not be stored in crawlspace.

## 2.0701.2b - Sign Content - Crawlspace Maintenance

**Cuidado, no dañar:**

**Si está dañado, estos deben ser reparados inmediatamente:**

**Si es necesario realizar alguna reparación, ponerse en contacto con:**

Hacer la señal en español también

## 3.1402.1c - Floor Plane Air Sealing: High Temperature Application

### Desired Outcome:

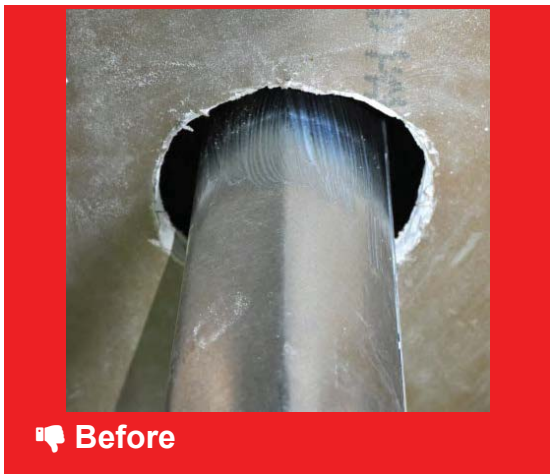
Air leakage prevented and indoor air quality protected

### Specification(s):

Only non-combustible materials will be used in contact with chimneys, vents, and flues in accordance with authority having jurisdiction

### Objective(s):

Prevent a fire hazard



Gaps around floor penetrations allow air and moisture movement



Use non-combustible materials, such as sheet metal and high-temp caulk

### Tools:

1. Caulk gun
2. Metal snips
3. Drill/screwdriver

### Materials:

1. High-temperature caulk, in accordance with ASTM E 136
2. Non-combustible sheet material

### 3.1402.1c - Floor Plane Air Sealing: High Temperature Application



1 Prepare work area by removing any insulation and debris



2 Use high-temperature caulking (600F min), in accordance with ASTM E 136



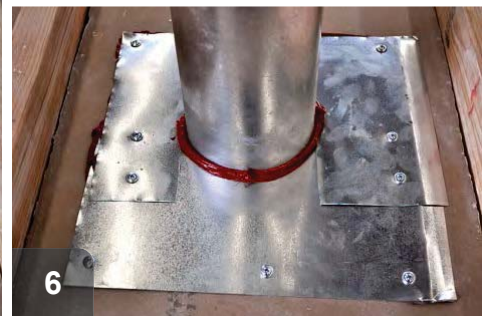
3 Apply first ring of caulking to match shape of opening



4 Apply second ring of caulking to size and shape of rigid material



5 Fasten rigid, non-combustible material and apply additional caulking



6 Fasten rigid, non-combustible material to cover penetration and seal against flue with caulk

Clearance to Combustibles for Combustion Appliance Vents		
Fuel	Vent type	Minimum Clearance to combustibles
Gas, LP	Type B gas vent	1"
	Single wall metal	6"
Fuel Oil	Type L vent	9"
	Single wall metal	18"
Solid Fuel	Type L vent	9"
	Single wall metal	18"
7 <sup>th</sup> fuel	Type L vent	per manufacturer's Specification

## 3.1402.3b - Pest Exclusion

### Desired Outcome:

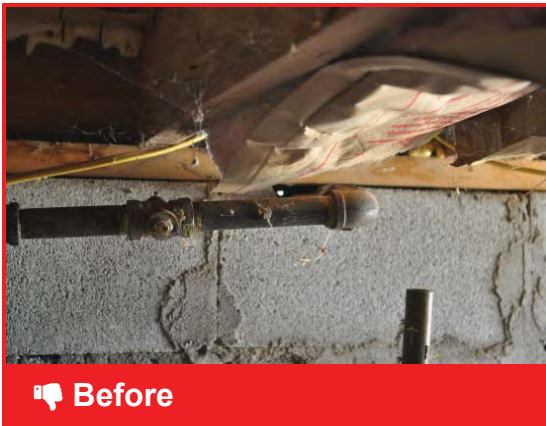
Well-sealed exterior wall prevents leakage and pests

### Specification(s):

If penetration is greater than ¼ inches, caulking, steel wool, or other pest-proof material will be used to fill the penetration before sealing

### Objective(s):

Prevent pest entry



For bigger holes, extra steps should be taken to keep out pests



Choose the backing and infill strategy that works best for the hole size

### Tools:

1. Caulk gun
2. Sprayfoam gun
3. Metal snips
4. Drill

### Materials:

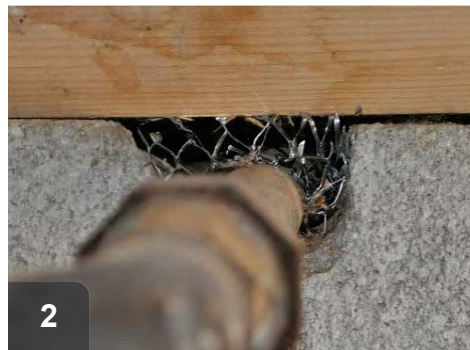
1. Caulk
2. Sprayfoam
3. Metal mesh
4. Rigid backing

Note: If there is evidence of pests entering vented crawlspace these same techniques can be used to exclude pests

## 3.1402.3b - Pest Exclusion



1 For holes larger than 1/4", rigid backing should be used to keep pests out



2 Metal mesh or other rigid materials should be cut to fill the space



3 Sprayfoam can be used to seal the hole and hold mesh in place

## 4.1301.1a - Sealing - Floor Plane Air Sealing

### Desired Outcome:

Consistent, uniform thermal boundary between conditioned and unconditioned space to prescribed R-value of an adjoining insulated assembly

### Specification(s):

Sealing the floor system will be completed before insulating

### Objective(s):

Ensure airtight envelope

Prevent leakage



**Before**

Gaps around penetrations can cause air leakage and negate insulation



**After**

Sealed penetrations maintain the air barrier

### Tools:

1. Caulk gun
2. Spray foam gun
3. Drill / impact driver

### Materials:

1. Caulk
2. Backer rod
3. Spray foam
4. Rigid sheet material
5. Fasteners

- Backing or infill will be provided as needed to meet the specific characteristics of the selected sealant and the characteristics of the penetration.
- The backing or infill will not bend, sag, or move once installed.
- Ensure resulting closure is permanent and supports any load (e.g., insulation).
- Ensure sealant does not fall out.
- Be alert to high-temperature flues and chimneys and use appropriate sealants and materials. See 3.1402.1c.

## 4.1301.1a - Sealing - Floor Plane Air Sealing



Locate gaps around penetrations for plumbing, electrical, etc.



Fill gaps greater than 1/4 inch with backer rod or spray foam



Caulk smaller gaps and to hold backer rod in place



open tub chase



Seal large tub chase using rigid, sheet material (foam board, sheet metal, plywood, etc) then caulk or foam edges

## 4.1301.1c - Securing Batt - Floor Insulation

### Desired Outcome:

Consistent, uniform thermal boundary between conditioned and unconditioned space to prescribed R-value of an adjoining insulated assembly

### Specification(s):

Batts will be secured with physical fasteners

### Objective(s):

Ensure insulation remains in contact with subfloor



Fiberglass batts must not hang away from subfloor. Fasteners must not compress batts.



Floor insulation twine and lath support

### Tools:

1. Utility knife
2. Drill
3. Staple gun

### Materials:

1. Batt insulation
2. Twine
3. Lath
4. Staples

Note: Insulation batt shall be sized to fill the cavity, installed in complete contact with underside of floor, and installed without voids, gaps, or compressions.

Please see Appendix D for Floor Support Matrix for support requirements using Twine or Lath.

## 4.1301.1c - Securing Batts - Floor Insulation



Batt must be in contact with subfloor without being overly compressed.



Twine fastened across bays in a zig-zag pattern

FLOOR SUPPORT MATRIX						
Floor Type	Support Material	Material requirements	Maximum Spacing	Acceptable patterns	Minimum fastener type	Minimum fastener depth
Joist up to 24"	Lath	3/8X1.5"	20" O.C.	Across floor joists	Corrosion resistant 3/8" crown 18AWG	5/8"
Joist up to 24"	Twine	150 LBS. polyester, polypropylene or nylon	12" O.C.	Shoelace Zigzag (must be stapled at each joist)	Corrosion resistant 3/8" crown 18AWG	5/8"
Post & Beam over 32" O.C.	Lath	3/8X1.5"	20" O.C.	Across floor beams up to 54". If over 54" need center support	Corrosion resistant 3/8" crown 18AWG	5/8"
Post & Beam over 32" O.C.	Twine	150 LBS. polyester, polypropylene or nylon	12"	Shoelace up to 54" across. If over 54" need center support	Corrosion resistant 3/8" crown 18AWG	5/8"

Required twine or lath support for floor insulation



Wire batt support rods (known as tiger teeth) are prohibited because they compress insulation, rust, and fall out.

## 4.1301.2b - Netting, Fabric - Dense Pack Floor Insulation

### Desired Outcome:

Consistent, uniform thermal boundary between conditioned and unconditioned space to prescribed R-value of an adjoining insulated assembly

### Specification(s):

When using netting or fabric, staples will be placed according to manufacturer specifications

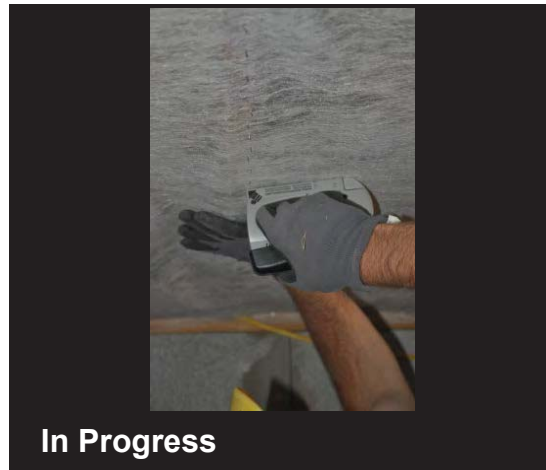
Netting or fabric will meet local fire codes

### Objective(s):

Secure insulation



**Before**  
Uninsulated floors above unconditioned spaces are an energy drain



**In Progress**  
Netting is secured to joists and sills to create cavities for insulation

### Tools:

1. Utility knife
2. Scissors
3. Stapler

### Materials:

1. Fabric netting
2. Staples

## 4.1301.2b - Netting, Fabric - Dense Pack Floor Insulation



1 Secure netting across each joist to create separate cavities



2 Secure netting across sills to prevent leakage of insulation



3 Keep netting taut while stapling to prevent wrinkles and leakage



4 Staples should be kept tightly together, placed no more than 1 1/2" apart

## 4.1401.2a - Preparation

**Desired Outcome:**

Closed crawl spaces insulated to achieve best thermal performance possible

**Specification(s):**

The rim joist, sill plate and adjacent surfaces will be sufficiently clean and free of debris to allow for the proper adhesion of any caulks, adhesives or spray foam used during installation.

**Objective(s):**

Prepare all surfaces for the installation of insulation



Use cleaning tools to remove debris and dirt that might prevent sealants from sticking to framing members

**Tools:**

1. Vacuum, compressed air, hand broom

## 4.1401.2b - Insulation Installation

**Desired Outcome:**

Closed crawl spaces insulated to achieve best thermal performance possible

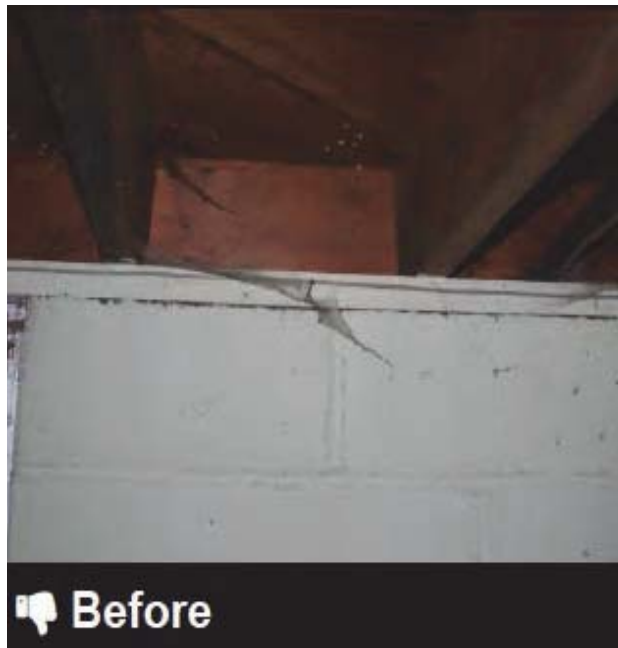
**Specification(s):**

Insulation and sealant will be installed so as to create a continuous thermal and pressure boundary.

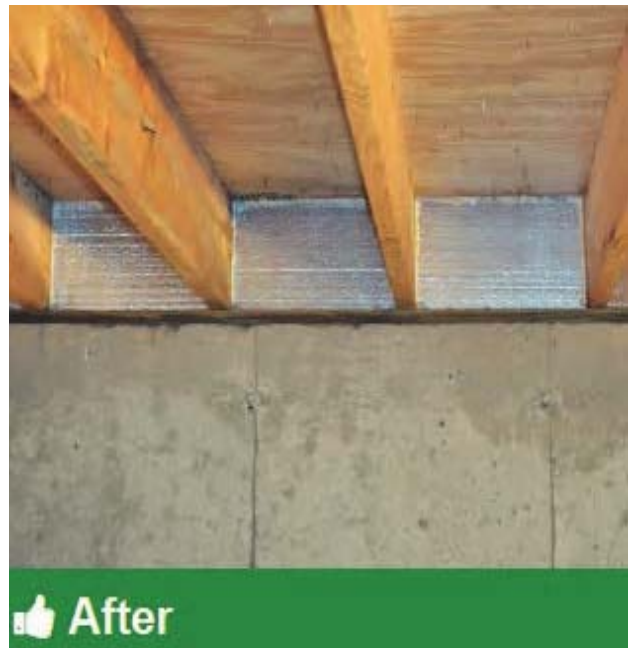
**Objective(s):**

Improve thermal performance

Prevent moisture condensation on the inside of the band joist



Uninsulated basement rim joist



Basement rim joist insulated and air sealed

## 4.1401.2b - Insulation Installation

### Tools:

1. Insulation knife
2. Measuring tape
3. Foam gun

### Materials

1. Insulation: rigid foam (DOW thermax; or R-max tSX 8500) or fiberglass batt with FSK (or MBI)
2. Sealant

This Specification is for basement or closed crawl application. Insulation must be a Class 1 material, according to ASTM E84 (flame spread not to exceed 25, smoke index not to exceed 450). Two rigid foam products meet this requirement: DOW thermax, and R-max tSX 8500.

Fiberglass batts shall be FSK or MBI to serve as vapor retarder.



1 Rim joists in a conditioned basement lack pressure and thermal boundaries.



2 Save time by pre-cutting pieces of rigid foam to fit between floor joists. Gaps will be air sealed.



3 Pressure fit rigid insulation into



4 Air seal all seams where insulation meets framing.



5 Cut insulation to fit around utility penetrations in rim joists. Air seal all seams.



6 Fiberglass needs vapor retarder facing. FSK batting or metal building insulation (MBI) are acceptable.

# 4.1005.2d, 4.1301.1d, 4.1103.1b - Onsite Documentation

## Desired Outcome:

Consistent, uniform thermal boundary between conditioned and unconditioned space controls the heat flow

## Specification(s):

A dated receipt signed by the installer will be provided that includes:

- Insulation type
- Coverage area
- R-value
- Installed thickness and settled thickness
- Number of bags installed in accordance with manufacturer specifications

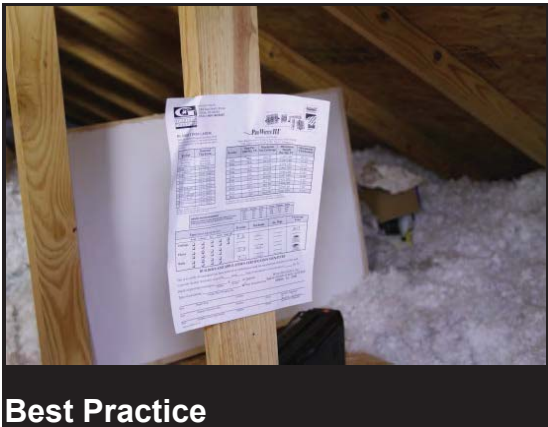
## Objective(s):

Document job completion to contract specifications

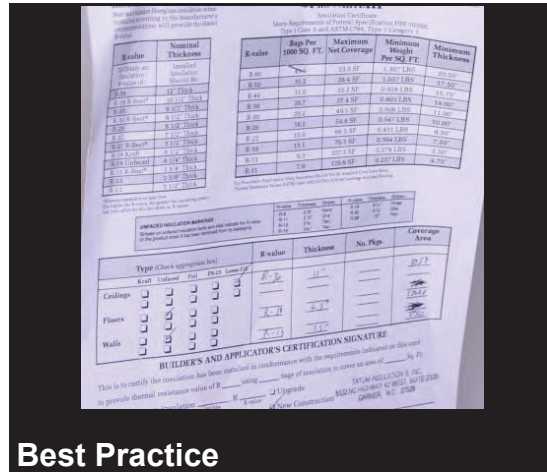
Confirm amount of insulation installed

Ensure ability to match bags required for total area completed

Comply with 16 CFR 460.17



**Best Practice**



**Best Practice**

Information on insulation installed should be posted nearby

Posted info includes insulation type, r-value, depth, coverage area, etc.

This requirement applies whenever insulation is installed.

Reference 16 CFR 460.17: The installer, must provide the customer or client documentation regarding the insulation installed. Documentation will indicate the coverage area, thickness, and

R-value of the insulation. The insulation certification must be dated and signed by the installer. Insulation certificate to be posted at entrance to attic or crawlspace and a copy shall be provided for project file.

To figure out the R-value of the insulation, use the data that the manufacturer gives you.

## 4.1103.1a - Exterior Dense Pack

**Desired Outcome:**

**Consistent, uniform thermal boundary between conditioned and unconditioned space to prescribed R-Value of an adjoining insulated assembly**

**Specification(s):**

**Using fill tube, 100% of each cavity will be filled to a consistent density:**

- **Cellulose insulation used in an enclosed cavity will be installed at 3.5 pounds per cubic foot or greater density**
- **Blown fiberglass, mineral fiber, or rock and slag wool used in an enclosed cavity will be installed at or above the manufacturer recommended density to limit air flow that corresponds to an air permeance value of 3.5 cfm/sq. ft. at 50 pascals, as measured using BPI-102 “Standard for Air Resistance of Thermal Insulation Used in Retrofit Cavity Applications – Material Specification” or ASTM C 522, E 283, or E 2178; the number of bags installed will be confirmed and will match the number required on the coverage chart**

**Insulation will be verified to prevent visible air movement using chemical smoke at 50 pascals of pressure difference**

**Objective(s):**

**Eliminate voids and settling**

**Minimize framing cavity air flows**



Make accurate count of insulation bags to be installed



Install insulation to correct density (at least 3.5 pounds per cubic foot for cellulose, or 1.5 pounds for fiberglass)

### Tools:

1. insulation blowing machine
2. pressure gauge
3. blower door
4. tools for removing siding: hammer, pry bar, knife
5. chemical smoke dispenser
6. drill
7. tape measure
8. ladder

### Materials:

1. cellulose or fiberglass insulation (any fiberglass material used must be specifically approved for air flow resistance by the manufacturer)
2. wooden, plastic, or foam plugs to fill installation holes
3. piece of fiberglass batt or towel to stop insulation from blowing out around the hose
4. Siding repair materials: caulk, exterior-grade spackle, primer/ paint

When possible, exterior siding shall be removed or lifted to gain access to the exterior wall for drilling. Score and snap method of siding removal is permitted when proper paint preparation is followed. Siding shall be replaced after insulation is installed. Any siding that is damaged shall be repaired or replaced with matching siding that is primed and painted to match existing siding.

Exterior siding not containing asbestos that cannot be removed or lifted before drilling walls may be drilled through with the owner's permission. Holes shall be drilled in a level line, and all holes will be filled with a tight-fitting, wooden plug that is installed using an exterior grade, non-silicone-based adhesive, and then filled and smoothed with exterior-grade spackle, textured to match existing surface(s), allowed to cure per manufacturer's specifications, primed, and painted to match existing siding.



1 Calculate the number of bags needed and verify the number you actually install.



2 Remove siding and drill holes in sheathing for installing insulation. Follow lead safe work practices when needed.



3 Only drill through the siding if it can't be removed. Follow lead safe work practices when needed.



4 Check that the static pressure at the blowing machine and at the hose end is at least 2.9 PSI.



5 Adjust the pressure (controls shown here) and the feed gate to fill an 8-foot wall cavity in 2 to 4 minutes.



6 With a rag or fiberglass batt to prevent insulation blowing out, fill all cavities in exterior walls with insulation.



7 Check to make sure all cavities are properly filled. One of these is empty, and another is not filled to proper density



8 Check that cavities are filled and are the proper density.



9 Check for air leakage reduction after dense-pack insulation using a blower door at -50 Pascals and smoke

## 4.1005.2d, 4.1301.1d, 4.1103.1b - Onsite Documentation

### Desired Outcome:

Consistent, thermal boundary between conditioned and unconditioned space controls the heat flow

### Specification(s):

A dated receipt signed by the installer will be provided that includes:

- Insulation type
- Coverage area
- R-value
- Installed thickness and settled thickness
- Number of bags installed in accordance with manufacturer specifications

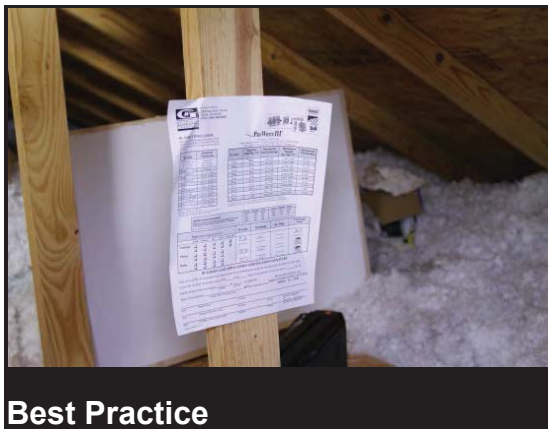
### Objective(s):

Document job completion to contract specifications

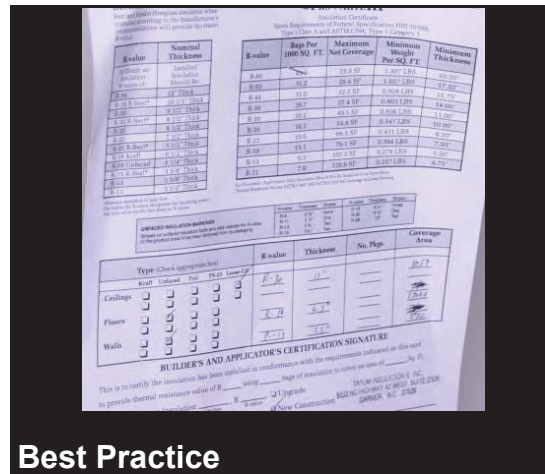
Confirm amount of insulation installed

Ensure ability to match bags required for total area completed

Comply with 16 CFR 460.17



**Best Practice**



**Best Practice**

Information on insulation installed should be posted nearby

Posted info includes insulation type, r-value, depth, coverage area, etc.

This requirement applies whenever insulation is installed.

Reference 16 CFR 460.17: The installer, must provide the customer or client documentation regarding the insulation installed. Documentation will indicate the coverage area, thickness, and

R-value of the insulation. The insulation certification must be dated and signed by the installer. Insulation certificate to be posted at entrance to attic or crawlspace and a copy shall be provided for project file.

To figure out the R-value of the insulation, use the data that the manufacturer gives you.

## 3.1501.1a - Penetrations

### Desired Outcome:

Openings from garage sealed to prevent leakage

### Specification(s):

All lighting fixtures, wiring, plumbing, venting, ducting, and gas piping penetrations will be sealed

### Objective(s):

Prevent air leakage and pollutant entry



 Before

Penetrations between the garage and house can leak hazardous fumes



 After

Seal penetrations to minimize risks and air leakage

### Materials:

1. Backer Rod
2. Caulk
3. Spray foam

## 3.1501.1b - Ductwork

### Desired Outcome:

Openings from garage sealed to prevent leakage

### Specification(s):

All joints and connections in ductwork will be fastened and sealed with UL 181B or 181B-M welds, gaskets, adhesive mastics, or mastic-plus- embedded-fabric systems

### Objective(s):

Prevent air leakage and pollutant entry



 Before

Unsealed joints and connections need to be sealed to prevent health risks.



 After

Sealed ductwork connections help prevent leakage.

### Materials:

1. Mesh tape
2. Mastic

## 3.1501.1b - Ductwork



Prepare work area by assessing any safety concerns.



Wrap joint with fiberglass mesh tape.



Apply UL 181 mastic to seal joint.

## 3.1501.1d - Garage to House Door

### Desired Outcome:

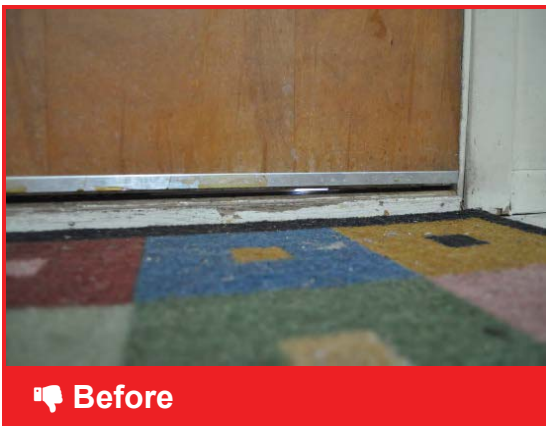
Openings from garage sealed to prevent leakage

### Specification(s):

Weather stripping, door sweep, and threshold will be installed to stop air leakage

### Objective(s):

Prevent air leakage and pollutant entry



Daylight visible under door to garage indicates leakage



Door sweep, with weatherstripping, will minimize air exchange with garage

### Tools:

1. Caulk gun
2. Screwdriver
3. Utility knife
4. Hacksaw
5. Saw
6. Tape measure
7. Drill
8. Planer

### Materials:

1. Weatherstripping (Q-lan)
2. Door sweep
3. Caulk
4. Fasteners

## 3.1501.1d - Garage to House Door



Remove door for access to work space and to install sweep



Measure for weatherstripping around door



Install weatherstripping into rabbit around door



Corners of weatherstripping should be snug and secure



Adjust threshold to minimize contaminant and water infiltration



Caulk along threshold to minimize water and contaminant infiltration



Cut door sweep to width of the door



Ensure door sweep fits tightly against bottom of door and fasten in place



Rehang door to verify snug fit and smooth operation

# Duct Sealing

## 3.1602.1

### Sealing Small, Medium & Large Holes

Specification(s):

All joints, seams, and connections in ductwork shall be securely fastened and sealed with UL 181-B-M mastics (adhesives) or mastic-plus-embedded-fabric systems installed in accordance with the manufacturer's instructions before insulation is applied.

Objective(s):

Minimize duct leakage

After gaining access to the leakage site, choose the appropriate sealing technique from below. Each of these step-by-step groupings illustrate a specific sealing technique based on the hole size. There are 3 sets to choose from:

(Small Holes) - Mastic + Mesh Tape:

Seams, cracks, joints, holes and penetrations that are 1/4-inch or less.

**(Medium Holes) – Temporary Tape + Mastic + Mesh Tape:**

Seams, cracks, joints, holes and penetrations that are 1/4-inch to 3/4-inch.

**(Large Holes) – Rigid Support + Mastic + Mesh Tape:**

Seams, cracks, joints, holes and penetrations that are larger than 3/4-inch.

**Materials:**

**Tools:**

- Mastic
- Fiberglass mesh tape
- Duct tape
- Sheet metal
- Support material
- Screws

- Utility knife or scissors
- Mastic brush
- Tin snips
- Flashlight/headlamp
- Drill

**Safety & Notes:**

Gloves, appropriate respirator, safety glasses

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## 3.1602.1 - Duct Sealing

### Sealing Small Holes

Seams, cracks, joints, holes and penetrations that are 1/4-inch or less.



Seal with mastic.



Notes:

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## 3.1602.1 - Duct Sealing

### Sealing Medium Holes

**STEP 1:** Seams, cracks, joints, holes and penetrations that are 1/4-inch to 3/4-inch.



**STEP 2:** Install temporary tape over seams, cracks, joints, holes and penetrations.



**STEP 3:** Apply a base coat of mastic to completely cover and extend beyond tape.



**STEP 4:** Apply fiberglass mesh tape to completely cover and extend beyond mastic.



## 3.1602.1 - Duct Sealing

### Sealing Medium Holes (cont.)

**STEP 5:** Apply a second coat of mastic atop fiberglass mesh tape to completely cover and extend beyond tape.



#### Notes:

Temporary tape can be a variety of different types of tape. It is used to prevent mastic from falling into the hole and should only be used if also using mesh tape for reinforcement.

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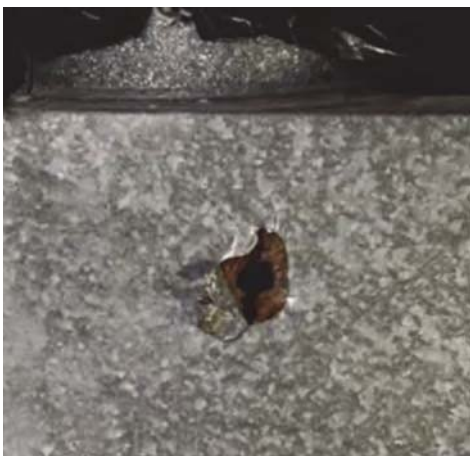
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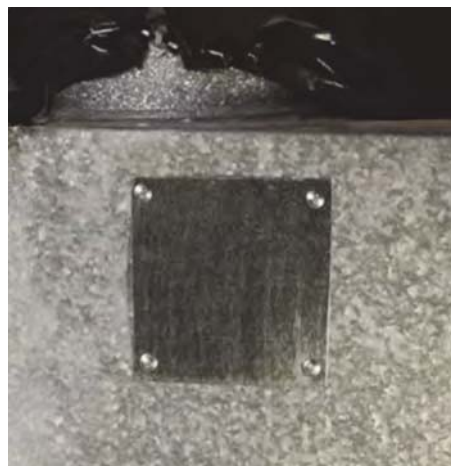
## 3.1602.1 - Duct Sealing

### Sealing Large Holes

**STEP 1:** Seams, cracks, joints, holes and penetrations that are larger than 3/4-inch.



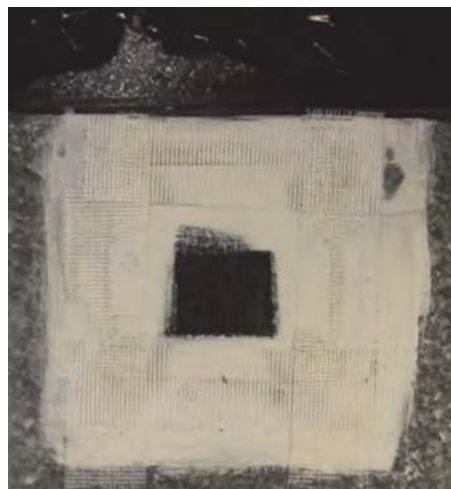
**STEP 2:** Install rigid duct support material that is at least 1 inch larger than the hole.



**STEP 3:** Apply a base coat of mastic to completely cover and extend beyond support material.



**STEP 4:** Apply fiberglass mesh tape to completely cover and extend beyond mastic.



## 3.1602.1 - Duct Sealing

### Sealing Large Holes (cont.)

**STEP 5:** Apply a second coat of mastic atop fiberglass mesh tape to completely cover and extend beyond tape.



Notes:

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## 3.1602.1 - Duct Sealing

### Sealing Large Holes

**STEP 1:** Seams, cracks, joints, holes and penetrations that are larger than 3/4-inch.



**STEP 2:** Install rigid duct support material that is at least 1 inch larger than the hole.



**STEP 3:** Apply a base coat of mastic to completely cover and extend beyond support material.



**STEP 4:** Apply fiberglass mesh tape to completely cover and extend beyond mastic.



## 3.1602.1 - Duct Sealing

### Sealing Large Holes (cont.)

**STEP 5:** Apply a second coat of mastic atop fiberglass mesh tape to completely cover and extend beyond tape..



Notes:

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## 3.1602.1 - Duct Sealing

### Sealing Large Holes

**STEP 1:** Seams, cracks, joints, holes and penetrations that are larger than 3/4-inch.



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**STEP 4:** Apply fiberglass mesh tape to completely cover and extend beyond mastic.





## 3.1602.1 - Duct Sealing

### Sealing Large Holes

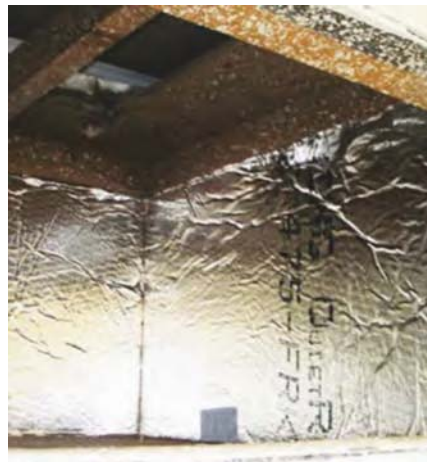
**STEP 1:** Seams, cracks, joints, holes and penetrations that are larger than 3/4-inch.



**STEP 3:** Apply a base coat of mastic to completely cover and extend beyond support material.



**STEP 2:** Install rigid duct support material that is at least 1 inch larger than the hole.



**STEP 4:** Apply fiberglass mesh tape to completely cover and extend beyond mastic.





## 3.1601.1c - Flex to Metal

### Desired Outcome:

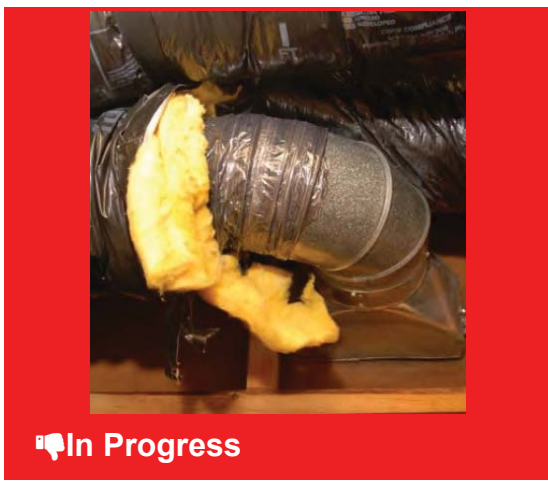
Ducts and plenums properly fastened to prevent leakage

### Specification(s):

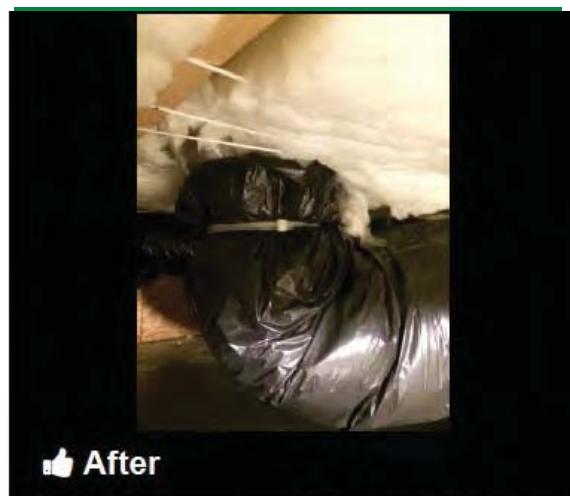
Joints will be fastened with tie bands using a tie band tensioning tool

### Objective(s):

Ensure durable joints



In Progress  
Inner liner of flex duct secured with panduit straps



After  
Outer covering secured with panduit strap.

### Tools:

1. metal snips
2. scissors or knife
3. panduit tensioning tool

### Materials:

1. heavy duty panduit straps

Use panduit-tensioning tool to secure all panduits. Use panduits to secure both the inner liner, and the outer insulation covering of the flex duct.



1  
Secure both inner liner and outer covering of flex duct with panduit straps. Tighten the straps with a tensioning tool.

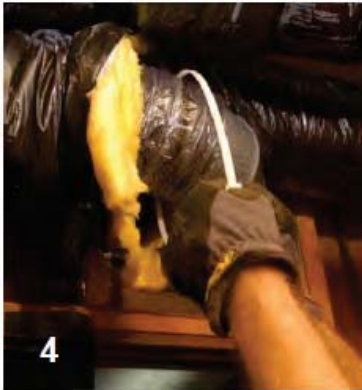


2  
If needed, eliminate duct sagging by shortening length of flex duct.



3  
Cutting the reinforcing wire will require metal snips or similar.

## 3.1601.1c - Flex to Metal



4 Place panduit strap around the connection.



5 Tighten panduit strap using a tensioning tool.



6 Pull flex duct insulation to cover rigid ducting, then secure outer covering over rigid duct with panduit strap.

## 3.1601.3a - Support (Applies to All Duct Types)

### Desired Outcome:

Ducts and plenums properly supported

### Specification(s):

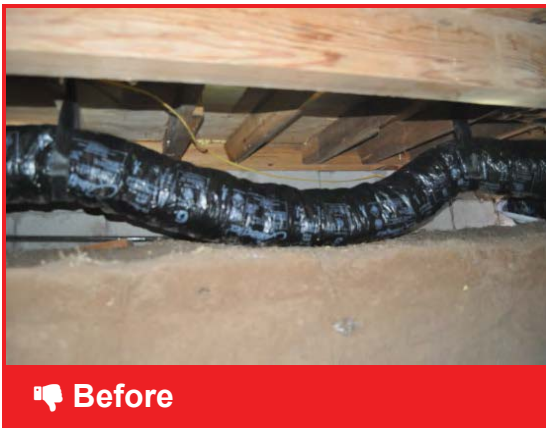
Flexible and duct board ducts and plenums will be supported every 4' using a minimum of 1 ½" wide material

Support materials will be applied in a way that does not crimp ductwork or cause the interior dimensions of the ductwork to be less than specified (e.g., ceiling, framing, strapping); duct support must be installed in accordance with authority having jurisdiction

Metal ducts will be supported by 1/2 inch wide eighteen gauge metal straps or 12-gauge galvanized wire at intervals not exceeding 10 feet or other approved means

### Objective(s):

Eliminate falling and sagging



Ducts should not be allowed to droop and drag, adding distance to run



Properly supported ducts minimize heat loss and maximize duct run

### Tools:

1. Metal snips
2. Utility knife
3. Drill
4. Stapler

### Materials:

1. 18 gauge metal strap (at least 1/2" wide)
2. 12 gauge galvanized wire
3. Synthetic fabric support straps (at least 1 1/2" wide)
4. Staples
5. Fasteners

### 3.1601.3a - Support (Applies to All Duct Types)



BAD: Make sure supports DO NOT compress insulation or duct



Flex ducts should have supports no less than every 4 feet



Durable strap should be at least 1 1/2 inches wide



Metal ducts should be supported every 10 feet or less with straps or wire



Metal straps should be at least 18 gauge and 1/2 inch wide



Metal wire should be at least 12 gauge and galvanized

## 3.1602.1c - Existing Component to Existing Component

### Desired Outcome:

Ducts and plenums sealed to prevent leakage

### Specification(s):

Fiberglass mesh and mastic will overlap temporary tape by at least 1" on all sides

Fiberglass mesh and mastic will become the primary seal

Seams, cracks, joints, holes, and penetrations larger than  $\frac{3}{4}$ " will be repaired using rigid duct material

Fiberglass mesh and mastic will overlap repair joint by at least 1" on all sides

Fiberglass mesh and mastic will be the primary seal

### Objective(s):

Eliminate air leakage into or out of ducts and plenums

Ensure adhesion of primary seal (fiberglass mesh and mastic) to the duct

Reinforce seal

Support fiberglass mesh and mastic during curing



Duct to plenum not sealed



Duct to plenum sealed

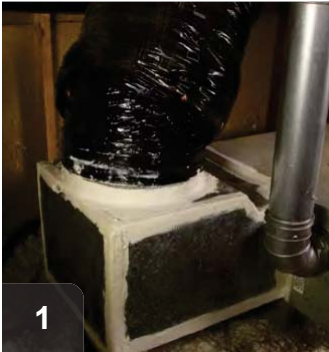
**Tools:**

1. Nylon strap tensioning tool

**Materials:**

1. Mastic
2. Fiberglass mesh tape
3. Nylon tensioning ties

## 3.1602.1c - Existing Component to Existing Component



Peel back outer layer of insulation, seal plenum with mastic using appropriate sealing technique based on hole size



Install nylon tie band around inner liner using a tie band tensioning tool.



Replace outer liner and insulation.



Install nylon tie band around inner liner using a tie band tensioning tool.

## 3.1602.4a - Duct Boot to Interior Surface

### Desired Outcome:

Ducts and plenums sealed to prevent leakage

### Specification(s):

All gaps between boot and interior surface that defines conditioned space will be air sealed

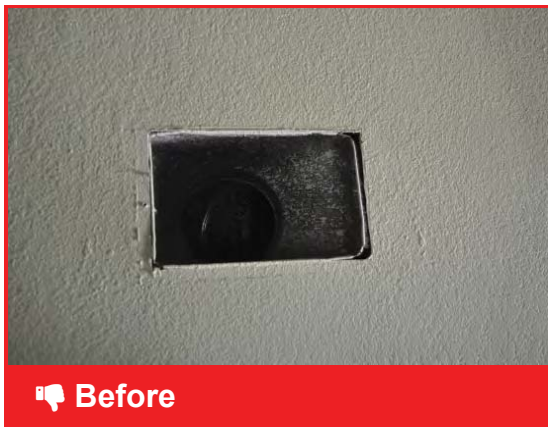
Gypsum edge will be wetted before applying water-based sealant

Sealants will be continuous and be in accordance with 2012 IRC R302.9

### Objective(s):

Prevent air leakage

Prevent a fire hazard



Gaps around duct boots allow for leakage to and from the attic



Use a mesh tape and mastic or UL 181 Aluminum Butyl Tape to seal duct boot to interior surface

### Tools:

1. Utility knife
2. Spray bottle
3. Putty knife
4. Drill motor or hammer

### Materials:

1. Mastic
2. Mesh tape
3. Fasteners (screws or nails)
4. UL 181 Aluminum Butyl Tape

Use fasteners to close any large gaps between interior surface and the duct boot

Use mesh tape and mastic or UL 181 Aluminum Butyl tape for gaps larger than 1/4 inch

When using mastic allow mastic to set before replacing register cover

## 3.1602.4a - Duct Boot to Interior Surface



Remove grill to expose duct boot and gaps



Use fasteners to close gaps before applying mastic



Wet the edges of the drywall to ensure a good bond



Cut mesh or UL 181 Aluminum Butyl tape to fit around duct boot and cover gaps



Apply mastic over tape to create heat resistant, durable bond



Once mastic is set, grill can be replaced and mastic should not show

## 3.1602.4c - Air Handler Cabinet

### Desired Outcome:

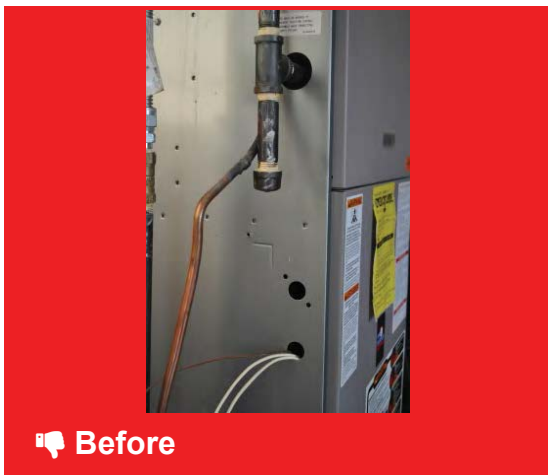
Ducts and plenums sealed to prevent leakage

### Specification(s):

Joints will be closed and cracks and holes not needed for proper function of unit will be sealed using removable sealant (e.g., foil tape) or in accordance with the original equipment manufacturer directions (if available)

### Objective(s):

Reduce air leakage while maintaining accessibility



**Before**

Unnecessary holes in the air handler cabinet need to be sealed



**After**

Use removable foil tape to seal holes

### Materials:

1. Foil tape

## 3.1602.4c - Air Handler Cabinet



Unnecessary holes in the air handler cabinet should be sealed



Removable foil tape should be used to seal



Fully cover holes with tape to seal completely

## 3.1602.4d - Filter Slot

### Desired Outcome:

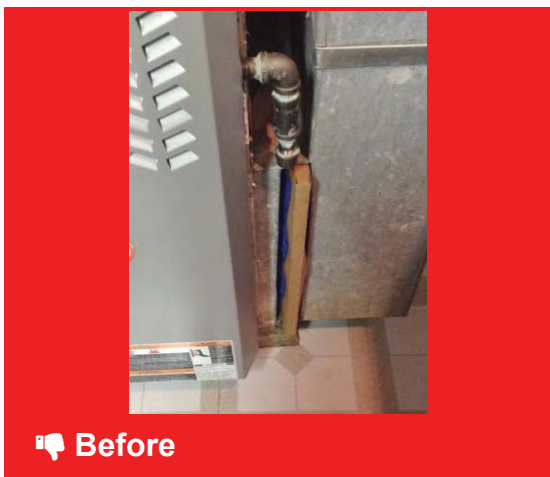
Ducts and plenums sealed to prevent leakage

### Specification(s):

A pre-manufactured or site manufactured durable filter slot cover will be installed

### Objective(s):

Reduce air leakage while maintaining accessibility



Uncovered filter slots are a point of leakage



Filter slots should be covered

## Return Ducts Inside Combustion Appliance Zone

### Specification(s):

Return ducts/plenums will be sealed according to 3.1601 and 3.1602 when located in a zone with an atmospheric combustion appliance.

### Objective(s):

Return duct leakage will not create depressurization in a zone where an atmospheric combustion appliance is located.

### Notes:

Return duct leakage allows the furnace fan to draw air from the surrounding area, depressurizing the zone. Sealing return leakage in combustion appliance zones may not be an energy measure, but will reduce depressurization which can cause spillage of exhaust gas from combustion appliances.



A forced air furnace and return ducts located in zone where atmospheric appliance (water heater) is present.



As the amount of return ducts in a zone increases, so does the chance of return duct leakage, which results in zone depressurization.

## Return Ducts Inside Combustion Appliance Zone



Pan joist return ducting is often leaky, creating depressurization in the zone.



Furnace filter slots located in the return plenum are often leaky, creating depressurization in the zone.



Furnace filter slots located in the return plenum are often leaky, creating depressurization in the zone.



Magnetic covers work well to seal leakage at the filter slot.

## Return Ducts Inside Combustion Appliance Zone



Magnetic covers work well to seal leakage in the filter slot.

## 3.1602.10b - Reduce Excess Flex Duct Length

### Desired Outcome:

Deliver air from trunk to termination (register/diffuser) without leakage

### Specification(s):

Excess flex duct will be removed between the takeoff at trunk and floor register boot

### Objective(s):

Improve air flow



 Before

This duct is far too long, resulting in poor airflow.



 After

The duct has been shortened, and is now properly supported.

## 3.1602.11d - Performance Testing

### Desired Outcome:

Ducts and plenums sealed to prevent leakage

### Specification(s):

Pre- and post-retrofit duct leakage will be performance tested using a duct blaster or pressure pan, and results will be documented and reported to the homeowner and/or program

### Objective(s):

Document post-retrofit duct leakage performed



#### Best Practice

Test duct performance using pressure pan or duct blaster, before and after work



#### Best Practice

Duct pressurization tests, before and after, can also be used to determine improvement in performance

### Tools:

1. Blower door
2. Manometer
3. Pressure Pan

Washington State weatherization workers will performance test duct sealing measures with pressure pan measurements. Duct pressurization tests, which quantify duct leakage (CFM@25), are also allowed.

## 3.1602.11d - Performance Testing



Set-up blower door to perform pressure pan testing



Perform pressure pan test on ductwork before beginning work. Record result



Perform pressure pan test after work is completed and compare to 'before' reading

## 4.1601.2a - Selection of Duct Insulation Material

### Desired Outcome:

Lowered thermal conductance of duct system and minimized condensation on the duct system

### Specification(s):

Duct insulation on all ducts located in unconditioned spaces will be a minimum of R-8, in accordance with local code, or buried under attic insulation, whichever is greater, and have an attached vapor retarder

Hot humid and warm coastal regions will not bury ducts

### Objective(s):

Decrease heat loss and condensation problems



 Before

Uninsulated ducts in unconditioned spaces are an energy drain



 After

Properly insulated ducts operate at much higher rates of efficiency

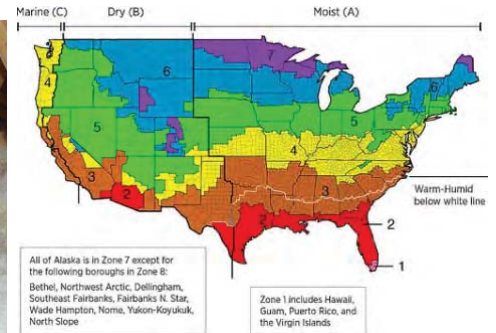
## 4.1601.2a - Selection of Duct Insulation Material



R-8 is the minimum insulation level in unconditioned spaces. Insulation requires a vapor retarder



Ducts can be buried in loose fill insulation in attic spaces.



Burying ducts is discouraged in warm coastal and hot, humid regions

## 4.1601.2c - Attachment of Duct Insulation

### Desired Outcome:

Lowered thermal conductance of duct system and minimized condensation on the duct system

### Specification(s):

Duct insulation will be secured to the duct system using metal wire or rot-proof nylon twine

Pattern of the wire or twine will be sufficient to securely hold the duct insulation tight to the duct

### Objective(s):

Ensure a secure connection between the duct system and the duct insulation



 Before

Materials holding insulation in place should not compress or kink duct



 After

Durable materials can be attached without compressing insulation

### Tools:

1. Scissors
2. Metal snips

### Materials:

1. Nylon twine
2. Wire
3. Tie bands

## 4.1601.2d - Taping of the Duct Insulation

### Desired Outcome:

Lowered thermal conductance of duct system and minimized condensation on the duct system

### Specification(s):

Using a tape approved by the manufacturer, all seams and connection of the duct insulation will be taped

No gaps will exist between pieces of duct insulation

### Objective(s):

Prevent gaps in the vapor barrier of the insulation



 Before

Unsecured and sealed insulation around ducts is useless



 After

All seams should be sealed with UL-181 duct tape to preserve vapor barrier

### Tools:

1. Utility knife

### Materials:

1. UL-181 tape
2. R-8 duct insulation with vapor barrier

# Bath Fan Installation

## Specification(s):

Exhaust fan will be installed to exhaust humidity and other pollutants out of the home.

## Notes:

All mechanical ventilation fan exhaust ducting (whole building and local) shall comply with the following:

- a. Extend directly to the outside of the structure (preferably through a vertical surface, rather than through the roof).
- b. All exhaust fans shall be equipped with a back draft damper located at either the fan outlet or the vent termination.
- c. Duct shall connect to a collar of the termination cap. Collar shall pass through the building envelope.
- d. Entire duct system, including termination cap shall have at least the equivalent net free area of the fan outlet.
- e. Ducting shall be constructed of rigid vent pipe material.  
Exception: Where rigid vent pipe is impracticable, flex duct may be used for runs no longer than 6 feet from fan to vent cap. For runs longer than 6 feet, flex duct may be used if the duct diameter is increased an additional 50% from the fan outlet diameter. In no installation shall the flex duct be allowed to loop. If one is running flex duct across varying heights (such as ceiling joists), the flex duct shall be stretched and secured to a splint to avoid sagging and the collection of condensation.
- f. Insulated to minimum R-8 with unfaced fiberglass insulation if it passes through unconditioned space.
- g. Air-tight and mechanically fastened at each joint using a minimum of 3 screws, including connection to the fan outlet and to the collar of termination cap. For metal ducting, the insert end of the duct shall extend into the adjoining duct or fitting the direction of airflow.

## Bath Fan Installation



Measure, mark, and cut hole for new fan. Plan for fastening to joists, blocking, or manufacturer's mounting brackets.



Install fan adapter first. Plan to ensure positive connection between adapter and fan housing.



Place new fan. Fasten to joist with screws and affix to mounting brackets in attic if applicable.



Complete fan mounting and air seal ceiling penetration.

## Bath Fan Installation



Assemble fan ducting.



Fasten fan ducting with minimum of three screws at each connection.



Exhaust fan ducted through vertical surface, still needs to be sealed, insulated, and supported if applicable.

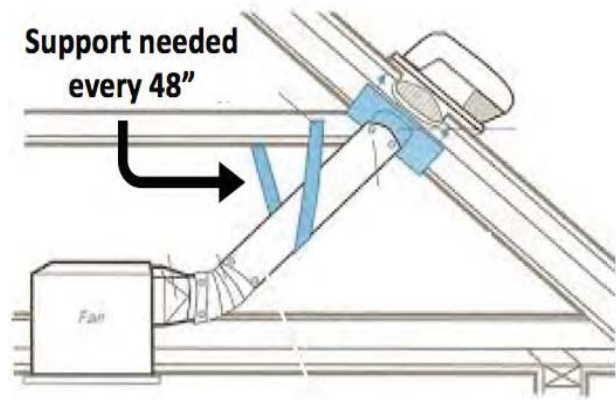


Seal exhaust fan duct seams with mastic of UL181 tape.

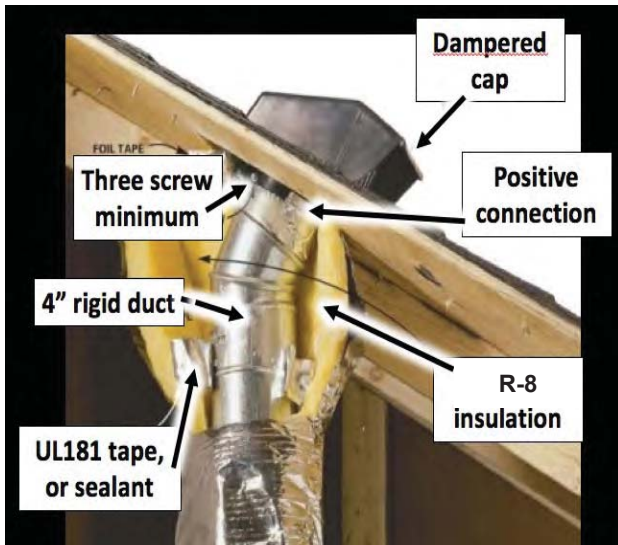
# Bath Fan Installation



Insulate exhaust fan ducting to R-8 when in unconditioned space.



Exhaust fan ducts require support every 48\".



Exhaust fan duct assembly showing damp-ered cap with collar.

## 6.6002.1a - Duct Design and Configuration

### Desired Outcome:

Installed ducts effectively move the required volume of air and prevent condensation

### Specification(s):

Ventilation ducts will be as short, straight, and smooth as possible

Ventilation ducts will not be smaller than the connections to which they are attached

### Objective(s):

Effectively move the required volume of air



 Before

Duct work for exhaust fans should be short, smooth, and shall not transition to smaller diameter.



 After

Duct is the same size as the outlet and makes shortest run possible

### Tools:

1. Metal snips
2. Drill
3. Nylon tie tensioning tool

### Materials:

1. Metal duct, or flexible duct materials with UL 181 listing or Air Diffusion Council approved.
2. Fasteners
3. Nylon tensioning ties
4. Sealant: mesh tape and mastic
5. Sealant: aluminum butyl tape with UL 181 listing

Listed flex-duct with the same inside diameter as the fan outlet shall not exceed 6' feet in length.

Exception: allowable flex duct length can exceed 6' provided diameter is increased by 50% (ie, 4" to 6").

## 6.6002.1b - Duct Insulation

### Desired Outcome:

Installed ducts effectively move the required volume of air and prevent condensation

### Specification(s):

Ducts installed outside of the thermal envelope will be insulated to a minimum of R-8 or equivalent to local codes

### Objective(s):

Prevent condensation from forming or collecting inside of the ductwork



 Before

Uninsulated fan venting



 After

Insulated fan venting prior to addition of loose fill cellulose.

### Tools:

1. Utility knife
2. Metal snips

### Materials:

1. R-8 insulation
2. Nylon twine
3. Wire

Exhaust fan venting insulation does not require a vapor barrier.

# Ventilation - Duct Support

## Specification(s):

### Metal venting support requirements

- a. Sections shall be securely connected to each other using a minimum of 3 screws for round ducts and 4 for rectangular.
- b. Horizontal and vertical duct runs shall be supported using nylon, plastic, or metal strapping having a minimum width of ½ inch. Support strapping or hangers shall not unduly compress the insulation.
- c. Support strapping or hangers shall be installed within 1 foot of a joint or connection with a maximum of 4 feet between supports.

### Flexible venting support requirements

- a. Flex duct, existing or installed, shall be insulated to a minimum, effective R-8.
- b. Flex duct shall be of the proper length for connection between two points without excessive bends or sag.
- c. Horizontal and vertical runs of flex duct shall be supported using nylon, plastic, or metal strapping having a minimum width of ½ inch. Support strapping or hangers shall not compress the insulation.
- d. Support strapping or hangers shall be installed within 1 foot of a joint or connection with a maximum of 4 feet between supports.
- e. Flex duct shall be connected to metal collars or boots. The inner layer of the flex shall be secured using a compression strap. The outer layer of insulation shall also be secured using a compression strap.

## Objective(s):

Effectively move the required volume of air, Preserve the integrity of the duct system, Eliminate falling and sagging;



Rigid vent material supported with nylon strapping

### Tools:

Tape Measure, Scissors or knife, Drill/driver

### Materials:

Nylon, plastic or metal strapping, fasteners

### Note(s):

WA Variance Allows

## 6.6002.2a - Hole in Building Shell - Roof Termination

### Desired Outcome:

Securely installed termination fittings with unrestricted air flow

### Specification(s):

A hole no greater than a 1/4" greater than the fitting will be cut to accommodate termination fitting

### Objective(s):

Allow for ease of weatherproofing



 **Before**

Exhaust fans need exterior ventilation, often through roofs and walls



 **After**

Hole should be no more than 1/4" larger than termination fitting diameter

### Tools:

1. Hole saw
2. Drill
3. Tape measure

## 6.6002.2a - Hole in Building Shell - Roof Termination



1  
Locate the center of your vent hole by drilling from inside through roof



2  
Measure the termination fitting to determine proper hole saw diameter



3  
Based on termination fitting size (in this case, 4"), mark to cut hole



4  
Hole should be no more than 1/4" larger than termination fitting diameter



5  
Verify hole size is correct before installation

## 6.6002.2b - Termination Fitting - Requirements

### Desired Outcome:

Securely installed termination fittings with unrestricted air flow

### Specification(s):

A termination fitting with an integrated collar will be used

Collar will be at least the same diameter as the exhaust fan outlet; if collar is larger than exhaust fan outlet, a rigid metal transition will be used

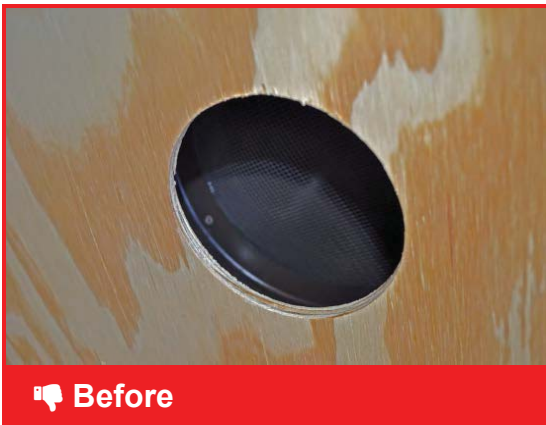
Fitting will be appropriate for regional weather conditions and installation location on house so as not to be rendered inoperable

### Objective(s):

Effectively move the required volume of air to the outside

Preserve integrity of the building envelope

Ensure durable installation



👎 Before

Termination fittings with no collar are to be avoided



👍 After

Properly sized ducts with snug connections to collared fittings last longer

### Tools:

1. Drill

### Materials:

1. Fasteners

## 6.6002.2b - Termination Fitting - Requirements



BAD: Termination fittings without collars should be avoided



Termination fittings with collars should be used for exhaust ventilation



Collared fittings extend through the roof to fasten securely with duct

## 6.6002.2d - Weatherproof Installation - Vent Cap

### Desired Outcome:

Securely installed termination fittings with unrestricted air flow

### Specification(s):

Exterior termination fitting will be flashed or weather sealed

Water will be directed away from penetration

Installation will not inhibit damper operation

Manufacturer specifications will be followed

### Objective(s):

Preserve integrity of the building envelope

Ensure a weather tight and durable termination installation

Ensure unrestricted air flow



 **Before**

Holes for termination fitting need to be sealed to weatherproof



 **After**

Termination installation should follow shingling to deter water penetration

### Tools:

1. Hole saw
2. Caulk gun
3. Drill

### Materials:

1. Fasteners
2. Caulk

## 6.6002.2d - Weatherproof Installation - Vent Cap



Termination fitting is installed to repel water and sealed

## 6.6002.2e - Pest Exclusion - Ventilation

### Desired Outcome:

Securely installed termination fittings with unrestricted air flow

### Specification(s):

Screen material with no less than 1/4" and no greater than 1/2" hole size in any direction will be used

Installation will not inhibit damper operation or restrict air flow

### Objective(s):

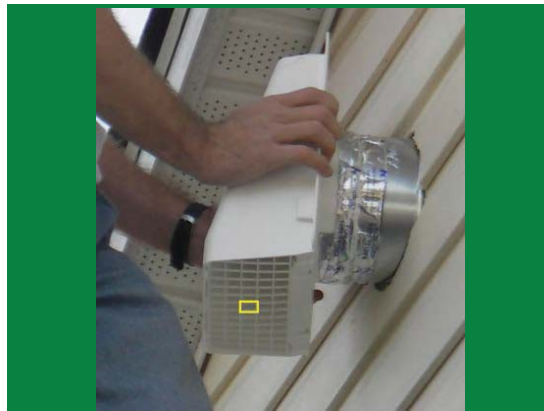
Prevent pest entry

Ensure proper air flow



 Before

Exhaust terminations without screens are an invitation to pest intrusion



 After

Screen mesh should be between 1/4" and 1/2" in either direction

## 6.6002.2f - Termination Location

### Desired Outcome:

Securely installed termination fittings with unrestricted air flow

### Specification(s):

Terminations will be ducted to the outdoors, which does not include unconditioned spaces such as attics and crawl spaces that are ventilated with the outdoors.

Terminations will be installed:

- A minimum of 3' away from any property line
- A minimum of 3' away from operable opening to houses
- A minimum of 10' away from mechanical intake
- As required by authority having jurisdiction

### Objective(s):

Prevent exhaust from reentering house



Exhaust vent has been improperly mounted too close to mechanical vent



Exhaust vent was properly mounted over 3ft from door, window, and deed line

### Tools:

1. Measuring tape
2. Hole saw
3. Drill

## 6.6002.2g - Kitchen Exhaust

### Desired Outcome:

Securely installed termination fittings with unrestricted air flow

### Specification(s):

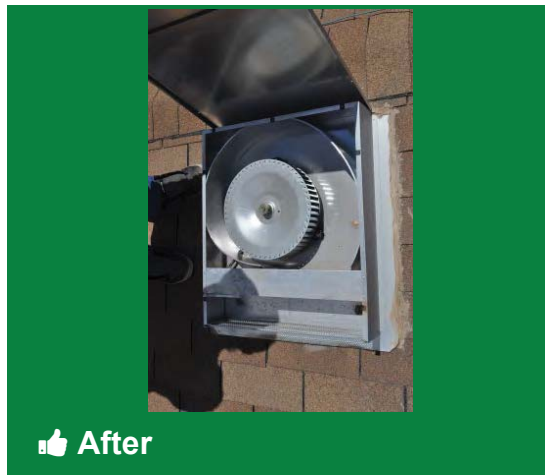
Galvanized steel, stainless steel, or copper will be used for termination fitting for kitchen exhaust

### Objective(s):

Prevent a fire hazard



Kitchen exhaust vents should not be made from highly combustible materials



This roof-mounted kitchen exhaust fan is galvanized steel--heat resistant

## 6.6003.3a - Hole in Building Shell - Sidewall Termination

### Desired Outcome:

Through the wall fans installed to specification

### Specification(s):

A hole no greater than a 1/4 inch greater than the assembly will be cut to accommodate fan assembly

### Objective(s):

Allow for ease of weatherproofing



 Before

Determine size to cut hole by measuring fan assembly and ducting



 After

A snug fit should be ensured to minimize weatherproofing required

### Tools:

1. Tape measure
2. Saw

## 6.6003.3a - Hole in Building Shell - Sidewall Termination



1 Measure the termination fitting to determine proper hole diameter (in this case, 4")



2 Hole should be no more than 1/4" larger than assembly diameter



3 Clear wall surface and mark hole size 1/4" larger than termination fitting



4 Since opening is larger than most hole saws, precision cutting is important

## 6.6003.3e - Backdraft Damper

### Desired Outcome:

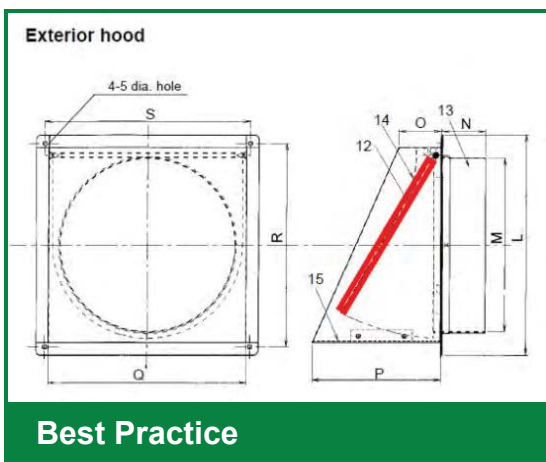
Through the wall fans installed to specification

### Specification(s):

A backdraft damper will be installed between the outlet side of the fan and the exterior

### Objective(s):

Prevent reverse air flow when the fan is off



Damper should be installed to maintain exterior air barrier

## 6.6003.3j - Preventing Air Leakage Caused by Exhaust Fans

### Desired Outcome:

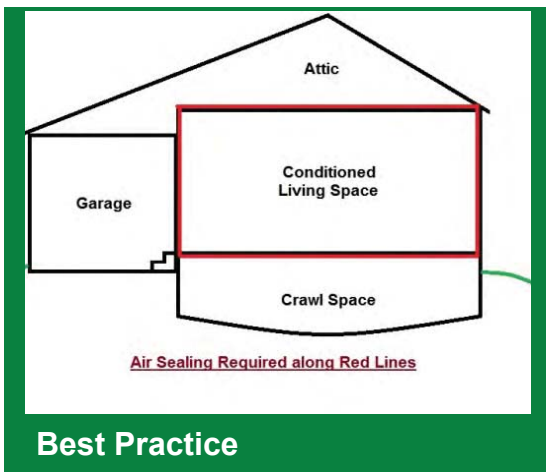
Through the wall fans installed to specification

### Specification(s):

Leakage to the house from other spaces will be prevented (e.g., garages, unconditioned crawl spaces, unconditioned attics)

### Objective(s):

Ensure occupant health and safety



The barrier between conditioned and unconditioned spaces should be sealed

See also SWS 3.1501.1 Air Sealing Garage Penetrations.

## 6.6005.1a - Clothes Dryer Ducting

### Desired Outcome:

Dryer air exhausted efficiently and safely

### Specification(s):

Clothes dryers will be ducted to the outdoors, which does not include unconditioned spaces such as attics and crawl spaces that are ventilated with the outdoors

As short a run as practical of rigid sheet metal or semi-rigid sheet metal venting material will be used in accordance with manufacturer specifications

Dryer ducts exceeding 35' in duct equivalent length will have a dryer booster fan installed

Plastic venting material will not be used

Uninsulated clothes dryer duct will not pass through unconditioned spaces such as attics and crawl spaces

Ducts will be connected and sealed as follows:

- UL listed foil type or semi-rigid sheet metal to rigid metal will be fastened with clamp
- Other specialized duct fittings will be fastened in accordance with manufacturer specifications
- In addition to mechanical fasteners, duct connections will be sealed with UL 181B or 181B-M listed material

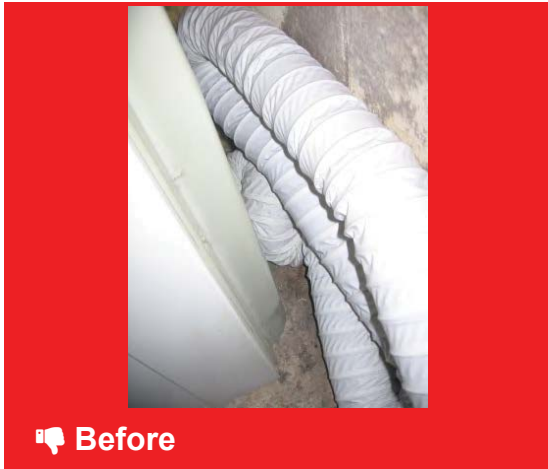
In addition:

- Sheet metal screws or other fasteners that will obstruct the exhaust flow will not be used
- Condensing dryers will be plumbed to a drain

### Objective(s):

Preserve integrity of building envelope

Effectively move air from clothes dryer to outside



**Before**

unacceptable dryer venting



**After**

Proper vent material and connection to collar at wall

### Tools:

1. crimper
2. panduit strap tensioning tool
3. knife
4. metal shears
5. tape measure

### Materials:

1. Aluminum UL 181 tape
2. Mastic
3. Mesh tape
4. Panduit straps
5. R-8 Insulation
6. 4 inch diameter, rigid venting material
7. 4 inch metal flex

In addition Clothes dryer venting installed shall comply with the following:

a. Vent shall terminate in a dampered vent cap. The exhaust vent shall terminate not less than 3 feet in any direction from openings into the building.

b. Have a smooth interior finish and shall be constructed of metal a minimum 0.016 inch (0.4 mm) thick. The exhaust vent size shall be 4 inches (102 mm) nominal in diameter.

c. The insert end of the venting shall extend into the adjoining venting or fitting in the direction of airflow.

d. Not exceed 35 feet in length from dryer location to outlet terminal. The maximum length shall be reduced two and one-half (2.5) feet for every 45 degree elbow and five (5) feet for each 90 degree elbow.

f. Both vertical and horizontal runs shall be supported using nylon, plastic, or metal strapping with a minimum width of ½ inch. Support strapping or hangers shall be installed within one (1) foot of a joint or connection and a maximum of every four (4) feet thereafter.

g. Dryer vents located in unconditioned space shall be insulated to a minimum R- 8.

Dryer transition piece:

The dryer transition piece is the venting component between the dryer and the point at which it goes through the wall, floor, or ceiling and leaves the vicinity of the dryer. This venting shall be listed and labeled in accordance with UL 2158A. Semi-rigid duct materials shall not be used as the transition piece. The transition piece shall not exceed eight feet in length and be long enough to allow for moving the dryer away from the wall, but not allow excess bending and kinking that can trap lint and water in the venting. The flexible transition piece shall not pass through a wall, floor, or ceiling. The transition piece shall connect to a smooth metal vent or a metal collar where it penetrates the ceiling, wall, or floor.

## 6.6005.1a - Clothes Dryer Ducting



1  
Dryer vent transition piece: panduit straps, metal collar at wall, foam air sealing



2  
Uninsulated dryer venting in unconditioned space



3  
Supported and Insulated dryer vent through unconditioned space. Venting slopes downward toward termination.

## 6.6005.1b - Termination Fitting

### Desired Outcome:

Dryer air exhausted efficiently and safely

### Specification(s):

Termination fitting manufactured for use with dryers will be installed

A backdraft damper will be included, as described in termination fitting detail

### Objective(s):

Preserve integrity of building envelope

Effectively move air from clothes dryer to outside



### Best Practice

Termination fittings for dryers should have backdraft dampers

## 6.6005.1b - Termination Fitting



Most modern dryer vents have a built-in backdraft damper

To minimize pest intrusion, mesh >1/4" square can be used (see 6.6002.2e)

## 6.6005.1d - Combustion safety

### Desired Outcome:

Dryer air exhausted efficiently and safely

### Specification(s):

Pressure effects caused by fans will be assessed and corrected when found outside of combustion safety standards

### Objective(s):

Ensure safe operation of combustion appliances

Ensure occupant health and safety



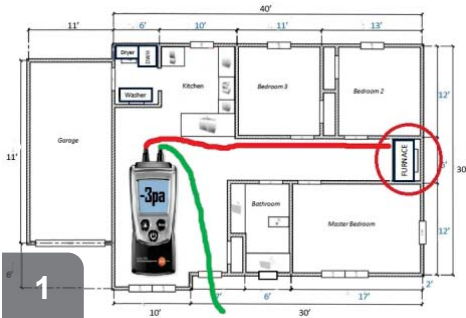
Appliance exhaust, such as that for a dryer, can cause depressurization



Test combustion appliances for spillage to confirm they comply with combustion safety standards.

### Tools:

1. Manometer



Perform worst case spillage test to ensure new exhaust ventilation isn't causing unsafe conditions



If spillage occurs, refer to Annex D on WA State combustion safety form.

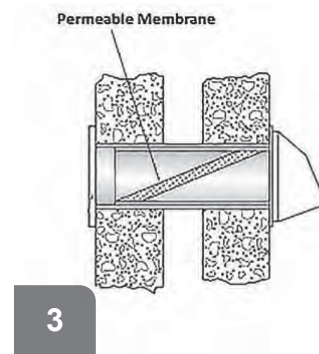
## 6.6005.1d - Combustion Safety



Run depressurization testing on house to ensure new ventilation isn't causing unsafe conditions



If depressurization limit is exceeded, mitigate to eliminate safety risk



Install make-up air, such as a passive inlet vent, or other pressure relief



After mitigation, verify that depressurization limit is not being exceeded

## 6.6005.2b - Fan Venting - Kitchen Fan

### Desired Outcome:

Kitchen range fan installed to specification

### Specification(s):

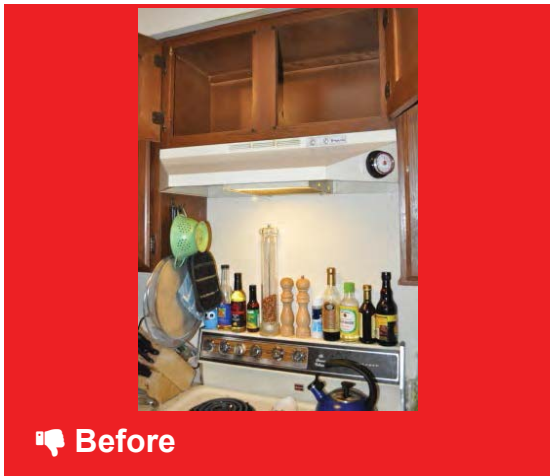
Kitchen range fans will be vented to the outdoors

Recirculating fans will not be used as a ventilating device

### Objective(s):

Remove cooking contaminants from the house

Preserve integrity of building envelope



Recirculating fans over ranges do not actually remove contaminants.



Kitchen exhaust vented to the outside and insulated when passing through unconditioned space.

### Tools:

1. Drill
2. Metal snips
3. Tape measure
4. Saw

### Materials:

1. Metal ducting
2. Sealant: mesh tape and mastic
3. Sealant: UL 181 listed tape
4. Fasteners

Kitchen range fans will be vented to the outdoors. As short a run as practical of smooth wall metal venting will be used.

Venting will be connected and sealed as follows:

- Metal-to-metal connections will be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, or tapes

- Other specialized vent fittings will be fastened in accordance with manufacturer specifications
- In addition to mechanical fasteners, vent connections will be sealed with [UL 181B](#) or 181B-M listed material
- Exhaust venting passing through unconditioned space will be insulated to a minimum R-8 and secured with twine or wire.

## 6.6005.2d - Termination Fitting - Kitchen Fan

### Desired Outcome:

Kitchen range fan installed to specification

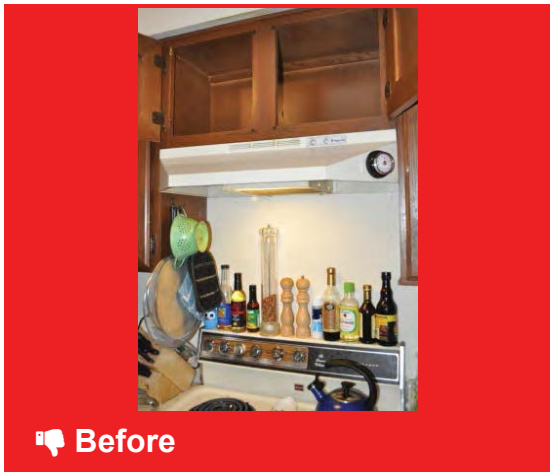
### Specification(s):

Termination fitting will be installed including a backdraft damper, as described in termination fitting detail

### Objective(s):

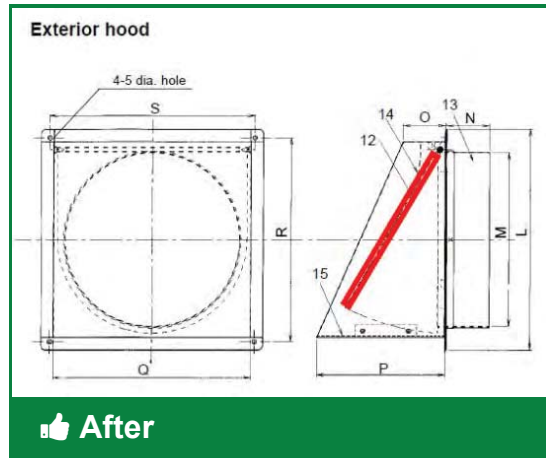
Ensure safe operation of combustion appliances

Ensure occupant health and safety



Before

Kitchen fans should exhaust to the exterior, not just recirculate air



After

Exhaust fans should have backdraft dampers

## 6.6005.2d - Termination Fitting - Kitchen Fan



Backdraft damper on roof mounted exhaust fan



An interior backdraft damper can also be installed for good measure

## 6.6005.2e - Make-Up Air - Kitchen Fan

### Desired Outcome:

Kitchen range fan installed to specification

### Specification(s):

Make-up air will be provided in accordance with the current version of ASHRAE 62.2 and in compliance with the authority having jurisdiction

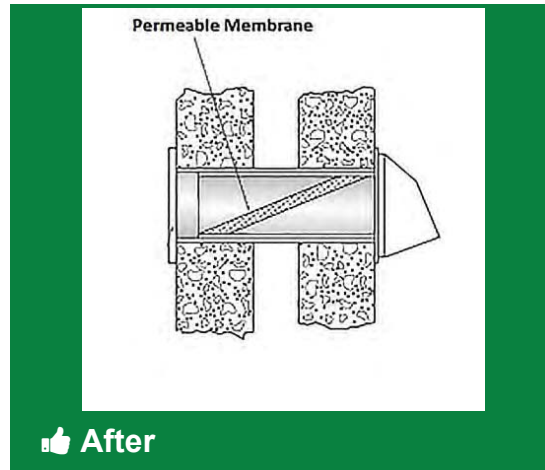
### Objective(s):

Ensure safe operation of combustion appliances

Ensure occupant health and safety



If kitchen exhaust is venting at more than 200 cfm, provide make-up air



A passive inlet vent can provide make-up air for kitchen exhaust

### Tools:

1. Drill
2. Hole saw
3. Caulk gun

### Materials:

1. Caulk sealant
2. Fasteners

## Air Handler>Pressure Balancing

### Desired Outcome:

Air circulates freely between rooms

### Specification(s):

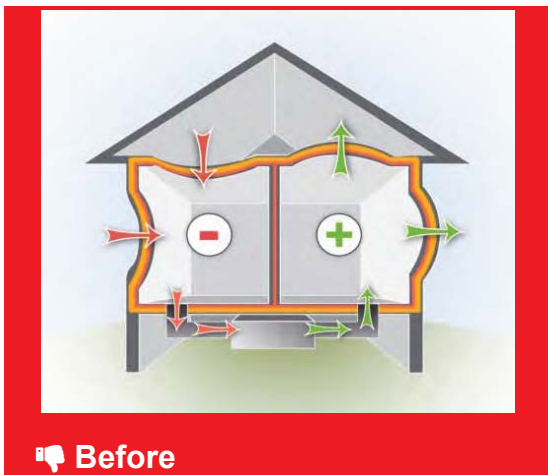
An appropriate means of pressure balancing will be installed (e.g., transfer grilles, jumper ducts, individual room returns)

The air handler shall not cause room pressures to exceed 5 pascals with reference to the main body of the house

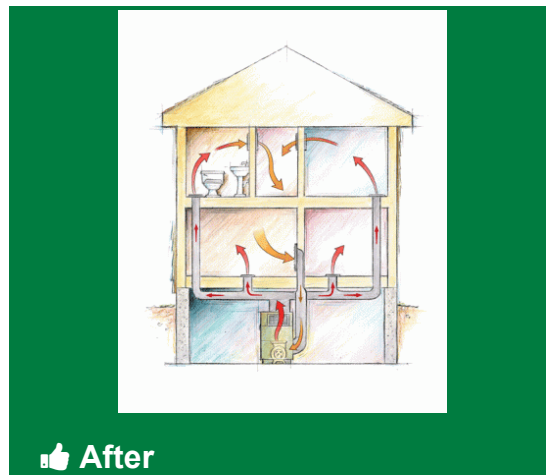
### Objective(s):

Ensure free flow of air between rooms

Preserve integrity of the building envelope



A forced air furnace can create excessive pressures and pressure imbalance between rooms and the main body of the house.



Pressure balancing allows conditioned air to flow freely in the home and reduces pressures behind closed doors.

**Tools:**

1. Undercut doors: circular saw, saw horses
2. Install transfer Grille: tape measure, saw, drill motor
3. Reduce supply airflow to area with high pressure: sheet metal tools, drill motor
4. Install jumper duct: saw, sheet metal tools, drill motor
5. Measure room pressures: manometer and probe/ hose

**Materials:**

1. Undercut doors: masking tape to prevent splintering
2. Install passive transfer grille: grille
3. Reduce supply airflow to area with high pressure: sheet metal, pre-fab damper, fasteners, mastic
4. Install jumper duct: ducting, fasteners, mastic



## 6.6201.2a - Balancing Pressure

### Desired Outcome:

Air circulates freely between rooms

### Specification(s):

An appropriate means of pressure balancing will be installed (e.g., transfer grilles, jumper ducts, individual room returns)

No room will exceed +/- 5 pascals with reference to the common area with all interior doors closed and ventilation systems running

### Objective(s):

Ensure free flow of air between rooms

Preserve integrity of the building envelope

### Tools:

1. Measure room pressures: manometer and probe / hose

Washington variance approved. Pressure limit is +/- 5 pascals



Locate the ventilation system, measure the pressure behind the door with reference to (WRT) main body of the house.

## 6.6202.1d - Manual Override

**Desired Outcome:**

Fan controls support ventilation strategy

**Specification(s):**

A labeled switch for manual override will be included for the ventilation system

**Objective(s):**

Ensure fan controls meet intended ventilation strategy

## 7.8102.2d - Emergency Drain Pan

### Desired Outcome:

Safe and reliable hot water source provided that meets occupant needs at lowest possible cost of ownership

### Specification(s):

When installing a replacement water heater, an emergency drain pan will be installed with side that extend a minimum of 2.5" above floor if leakage would cause damage to the home and in accordance with P2801.5 of the 2012 IRC

A ¾" drainline or larger will be connected to tapping on pan and terminated in accordance with P2801.5.2 of the 2012 IRC

### Objective(s):

Collect and safely dispose of water escaping from the storage tank



 Before

Water leak from a failing water heater will damage a home.



 After

New installation requires proper emergency drain pan with drain line plumbed to daylight.

## 7.8102.2k - Discharge Temperature - Insulating Tank and Supply Lines

### Desired Outcome:

Safe and reliable hot water source provided that meets occupant needs at lowest possible cost of ownership

### Specification(s):

Discharge temperature will be set not to exceed 120° or as prescribed by local code

### Objective(s):

Ensure safe hot water supply temperature to fixtures



**Unsafe**

Water heaters producing water over 120 degrees raise heating costs



**Safe**

Water heaters should produce water under 120 degrees to prevent scalding

### Tools:

1. Thermometer

Plumbing code defines hot water as water at a temperature at or greater than 110 degrees F (43 degrees C).

## 7.8102.2k - Discharge Temperature - Insulating Tank and Supply Lines



1  
Test temperature of hot water at faucets in house



2  
Hot water temperatures should not exceed 120 degrees Fahrenheit



3  
Adjust water heater settings and insulate as needed



4  
After adjustment and insulation, retest to verify temp is under 120 degrees

## 7.8103.1c - Thermal efficiency

### **Desired Outcome:**

Safe, reliable, and efficient operation of the appliance maintained

### **Specification(s):**

Water heater storage tanks shall have a minimum R-value of R-24

Added insulation will not obstruct the unit's draft diverter, pressure relief valve, thermostats, hi-limit switch, plumbing pipes or elements, and thermostat access plates

The first 6' of inlet and outlet piping will be insulated in accordance with IRC or local requirements, whichever is greater

### **Objective(s):**

Reduce standby losses from near tank piping and storage tank

Ensure insulation does not make contact with flue gas venting



Standard water heaters have built-in insulation ranging from R-7 to R-20.



Storage-type water heaters should be wrapped to bring total value to R-24

**Tools:**

1. Scissors
2. Utility knife
3. Outward clinching staple gun

**Materials:**

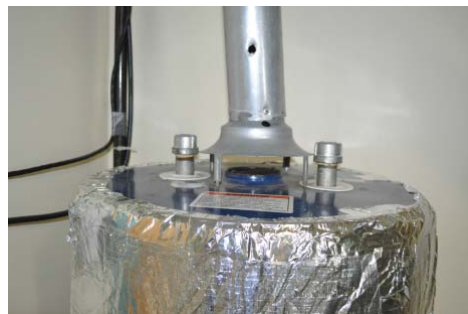
1. Insulation blanket
2. Plastic zip ties
3. Tape
4. Staples

Determine the R-value of the existing water heater by A) searching the internet using the model number or B) measuring the thickness of the existing insulation and multiplying by 3.14 per inch for fiberglass or 6.25 per inch for foam. Add insulating wrap to achieve at least R-24. R-values may be added, so a tank with a factory-installed R-value of R-6 would need an additional R-18 to reach the desired value of R-24.

Maintain 2" clearance between insulation and the draft diverter. Cut out around thermostats, pressure relief valves, and other items listed in the specification.



Check occupant's water heater model to see what r-value is built-in



Blanket does not obstruct draft diverter or plumbing pipes and elements



Wrap does not obstruct ventilation, thermostat access plate, hi-limit switch, or fuel line



Data plate should still be accessible after wrapping



Both hot and cold water pipes should be insulated to R-3 for first 6ft

## 7.8103.1e - Temperature and Pressure Relief Valve

### Desired Outcome:

Safe, reliable, and efficient operation of the appliance maintained

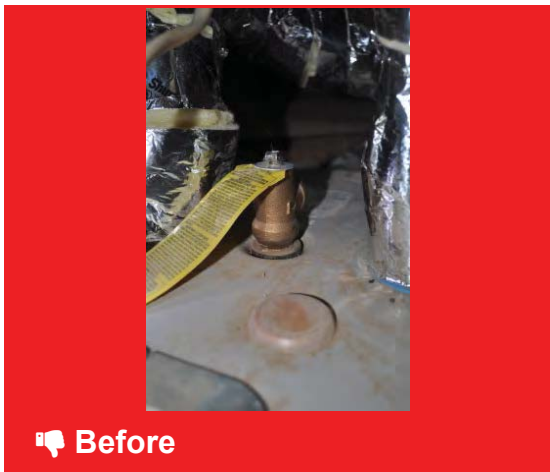
### Specification(s):

Correct temperature and pressure relief valve will be installed in compliance with P2803 of the 2012 IRC and according to manufacturer specifications

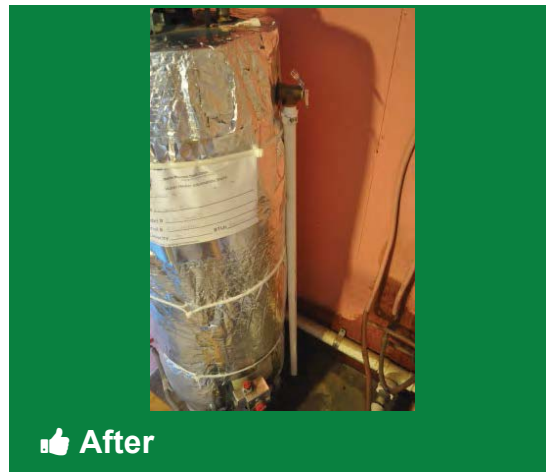
Temperature and pressure relief valve discharge tube will be installed in accordance with P2803.6.1 of the 2012 IRC

### Objective(s):

Discharge excessive energy (pressure or temperature) from storage tank to safe location



Water heaters should be not capped off at t&p valve



T&P discharge should be piped to a safe and observable location

### Tools:

1. Pipe wrench
2. Hacksaw

### Materials:

1. PVC approved for high temperature
2. Plumber's epoxy
3. Copper pipe

Check local jurisdictional codes. reference 2012 IRC P2803.6.1: Temperature and pressure relief valve discharge pipes should not be connected to drainage system. T&P discharge pipes should be a clean line without valve or tee, flowing with gravity to an observable and safe location that cannot cause personal injury or structural damage -- the floor, an existing drain pan, a waste receptor, or to the outdoors. Pipe should not terminate more than 6" from floor, pan or waste receptor.

## 7.8103.1e - Temperature and Pressure Relief Valve



GOOD: T&P discharge should be piped within 6" of the floor or to outdoors



BAD: T&P discharge should flow with gravity and be observable



BAD: T&P discharge should not be piped into drainage system

# Water Pipe Insulation

## Water Pipe Insulation

### Specification(s):

1. The Local Agency shall install insulation on accessible hot and cold water lines.

Exceptions: Water pipes shall not be insulated if any of these conditions are present:

- a. Water pipes or valves are leaking or are improperly supported.
- b. When electric heat tape is being used to prevent freezing of pipes and heat tape manufacturer does not approve product for insulation coverage.

2. Pipe insulation R-value: Water pipe insulation installed by the Local Agency shall have a minimum effective insulation value of R-3.

- a. Insulate the first 6 feet of both cold-water inlet and hot-water outlet pipes beginning at the water heater tank.
- b. Insulate hot and cold water distribution pipe in unconditioned space.

3. Installation standard for foam pipe insulation: Insulation shall be installed to these standards:

- a. Insulation with a lengthwise slit shall be positioned on horizontal pipe so that the slit is on the bottom side of the pipe.
- b. Insulation shall be sized to fit and firmly secured to the pipe. Products that are glued shall use the manufacturer's recommended adhesive and all slits in the material shall be sealed. Products that are not glued shall be held in place with elasticized tape, wire, or plastic ties. Elasticized tape shall be applied every nine (9) inches on center, and around each joint between separate pieces of material.

If ties are used, they must be made of either galvanized wire or non-slipping plastic. The ties shall be spaced at one inch from each end of the material and thereafter every nine (9) inches on center. Other techniques for attaching pipe insulation may be acceptable if approved in writing by Commerce.

Insulation material shall be cut and folded, or otherwise molded, to completely cover all elbows or curved pipe without compressing the insulation or allowing gaps to occur in the insulation.

4. Installation standard for fiberglass: If fiberglass batts are used, then the batts shall be at least R-7 when flat. After installation a minimum of R-3 shall be present on any water pipes, including piping for refrigerator ice makers that are not enclosed within the floor insulation. The insulation shall be permanently attached to the pipe with wire, cable ties, twine, strapping tape, or by other approved methods. Materials used to attach the fiberglass shall be spaced at one inch from each end of the fiberglass insulation and thereafter every nine (9) inches on center. Waste or drain pipes are excluded from this insulation requirement. Water pipes that are protected by (enclosed within) installed floor insulation are not required to be separately wrapped.

5. Insulation of pipes exposed to weather: If insulation is installed on pipes exposed to the weather, then such insulation shall be resistant to degradation from moisture, ultraviolet light, and extremes in temperature, or a jacket or facing shall be installed that protects the insulation from these conditions.

**Objective(s):** Prevent heat loss and pipe freezing in unconditioned spaces.

# Water Pipe Insulation

**Tools:**

1. Utility knife
2. Tape measure

**Materials:**

- Foam pipe wrap
- Fiberglass batt insulation
- Elasticized tape
- Wire
- Plastic ties



Water supply lines insulated with R-3 foam pipe wrap



**Foam pipe wrap**



Insulate the first 6 feet of both cold-water and hot-water outlet pipes beginning at the water heater tank

## 2.0100.2k - Heat and Thermal Stress

### Desired Outcome:

Work completed safely without injury or hazardous exposure

### Specification(s):

Ensure staff is aware of risks during summer months, including the symptoms of heat stroke and heat exhaustion

Appropriate ventilation, hydration, rest breaks, and cooling equipment will be provided

911 will be dialed when necessary

### Objective(s):

Prevent heat stroke, heat stress, and cold stress related injuries



Attics and crawl spaces can be dangerous work places in the heat



Keep workers comfortable with hydration and cool vests

Excessive heat easily builds up in attic spaces. When the heat in these spaces is enough to overcome a worker and prevent them from exiting without assistance, it is known as a thermal hazard. Prevent worker exposure to thermal hazards with the following measures:

- reduce the temperature in the space with mechanical ventilation.
- ensure workers are drinking plenty of water
- workers will wear *cool vests*
- reschedule work for times when those spaces do not present thermal hazards

## 2.0602.1a - Rigid Fill Tube

### Desired Outcome:

Prevention of static electric shock to the insulation installer when using rigid tubing

### Specification(s):

Rigid fill tubes will be made of a material that will not hold an electric charge, such as Schedule 40 PVC Electrical Conduit, or be grounded

### Objective(s):

Prevent injury to the installer



### Best Practice

Rigid fill tubes should be low-conductivity and be grounded

### Tools:

1. Wrench

### Materials:

1. Couplers
2. Schedule 40 PVC fill tube
3. Grounding wire
4. Grounding rod

## 2.0602.1a - Rigid Fill Tube



1  
Select rigid fill tubes that are low conductivity -- Schedule 40 PVC fill tube



2  
Attach grounding wire to fill tubes to minimize shock risk



3  
Attach grounding wire to rod with coupler



4  
Blow insulation

## 2.0602.1b - Metal Coupler Grounding

### Desired Outcome:

Prevention of static electric shock to the insulation installer when using rigid tubing

### Specification(s):

For an additional level of protection, the metal coupler on the hose will be connected to the grounding wire

Grounding wire will be connected to the grounding rod

Grounding rod will be driven into the ground a minimum of 8' when possible; grounding wire will be connected in compliance with local code and authority having jurisdiction

### Objective(s):

Divert static discharge of electricity to ground instead of installer



**Unsafe**

Ungrounded fill tubes can build up static electricity during insulation blowing



**Best Practice**

Fill tubes should be grounded to prevent electric shock to workers

### Tools:

1. Sledgehammer
2. Wrench

### Materials:

1. Grounding rod, at least 8'
2. Grounding wire
3. Metal coupler
4. Grounding coupler

## 2.0602.1b - Metal Coupler Grounding



Copper grounding rod should be at least 8' long



Grounding rod should be driven into the ground so that nearly all of rod is underground



Attach grounding wire to rod with coupler



Attach grounding wire to fill tube



Blow in insulation with peace of mind that workers will not be electrocuted

## 2.0204.1b - Air Seal Closet

### Desired Outcome:

Isolate combustion water heater closet from conditioned space

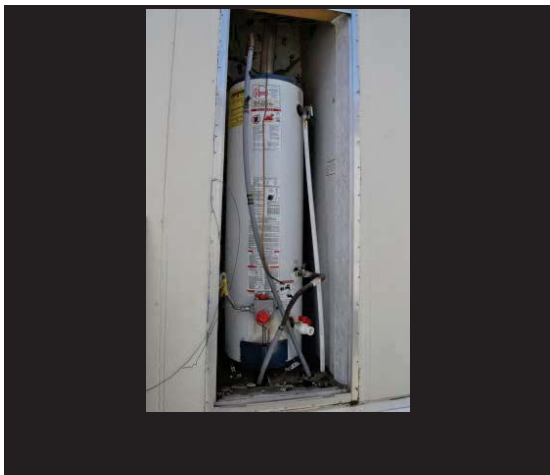
### Specification(s):

When the water heater closet contains a heater that is not sealed combustion or power vented, the closet will be isolated/separated from the rest of the home through air sealing with fire-rated materials, if feasible

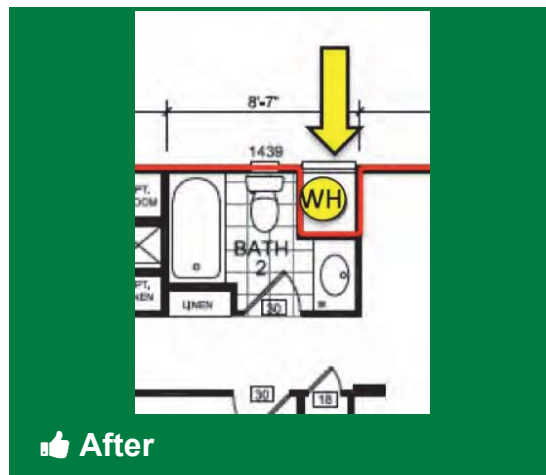
Avoiding frozen pipes must be considered without creating an additional utility burden (e.g., heat tape)

### Objective(s):

Prevent combustion gases from entering living area and minimize extension of interior pressures caused by exhaust fan, dryers, and interior door closure into the water heater closet



Water heaters that are open combustion must be isolated from the conditioned space by air sealing the closet.



👍 After

Air sealing the water heater closet has established the pressure boundary around the water heater, isolating it.

### Tools:

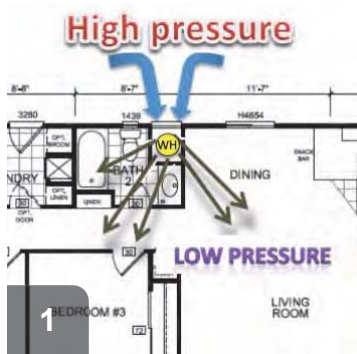
1. Caulk gun
2. Single-component foam gun
3. Manometer, hoses, pressure probes

### Materials:

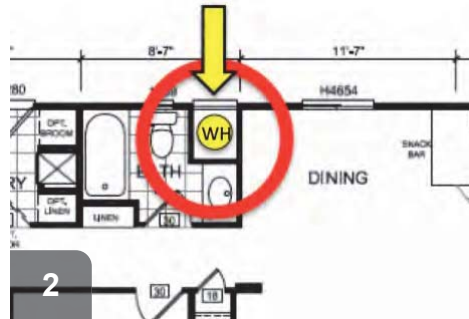
1. Caulk/ foam sealant
2. Water line insulation

If combustion make-up air is needed for proper combustion appliance operation upon completion of isolating the water heater, refer to Specification 2.0201.2a - Outside combustion make-up air.

## 2.0204.1b - Air Seal Closet



Before the water heater closet is isolated, combustion gases can be pulled into the living space.



Locate the combustion water heater, determine the materials needed to air seal the closet.



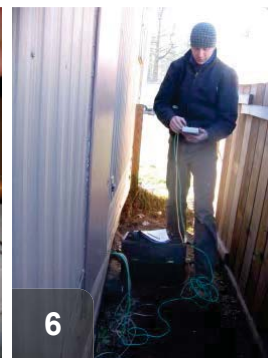
Air seal the water heater closet to eliminate all air pathways from the closet into the living space.



After air sealing the closet, the water heater is isolated from the rest of the house.



Use pressure diagnostics and Washington State combustion safety testing to confirm the appliance operates safely.



Due to limited space in water heater closets, perform pressure diagnostics and combustion safety tests from outside.

## 4.1003.8a - Attic, Ceiling, and Roof Verification

### Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

All combustion appliance flues will be terminated to the outdoors and terminations will maintain proper clearance above snow loads

A distance no less than 2" will be maintained between any combustion appliance flue and combustible materials, unless zero clearance flue is in place.

All ventilation systems will maintain a continuous connection and terminate to the outdoors

All broken mushroom vents will be replaced or removed and sealed

All plumbing stacks will be terminated to the outdoors

Non-IC rated light fixtures will be replaced with air-tight IC-rated fixtures or air-tight damming will be installed around existing Non IC-rated fixture when access allows

All recessed lights will be labeled as having an air leakage rate no more than 2.0 CFM when tested in accordance with ASTM E 283 at a 75 pascals pressure differential

All obvious ceiling penetrations will be sealed

The space between combustion appliance flues and the ceiling will be sealed with fire-rated materials

All roof, attic, and ceiling assemblies will be structurally sound; loose ceiling panels will be secured

Temporary ceiling bracing will be recommended during the insulation installation process

All known roof water leaks will be repaired before insulation installation

### Objective(s):

Ensure occupant and worker safety

Verify attic space is ready to insulate

Ensure structural integrity of the roof and ceiling assembly

Prevent intrusion of bulk moisture

Prevent damage during the insulation installation process



Roof leak, missing cap on vent



Properly connected and sealed roof vent

**Tools:**

1. Scaffolding and ladders
2. Screw gun
3. Long, flat prybar
4. 5-in-one paint scraper tool
5. Flashlights and headlamps
6. Digital camera

**Materials:**

1. Wooden blocks

Inspect and correct each of the specified items: flues terminated to outside, 2" clearance to combustibles from flues, ventilation ducts terminated outdoors, non-airtight, non-IC rated recessed lighting replaced with airtight, IC-rated recessed units or air sealed from above, broken mushroom vents replaced or removed, plumbing vents terminated outdoors, ceiling penetrations sealed, structural defects in roof, attic, and ceiling assemblies corrected, and all roof leaks repaired.

## 4.1003.8a - Attic, Ceiling, and Roof Verification



1 Inspect roof for evidence of water pooling, leaks, or damage. Verify proper vent terminations



2 Inspect ceiling for weakness, leaks, clearance to combustibles, loose panels, and penetrations



3 Verify presence of rain caps on all vents



4 Inspect all patches and repairs, and correct deficiencies if necessary



5 Verify at least 2" clearance to combustibles, unless flue is designed for zero clearance. Repair if needed



6 Use temporary supports to avoid ceiling collapse during insulation install



7 Add fasteners wherever needed to firmly attach ceiling to the trusses



8 Investigate all water stains and sources of moisture. Repair before insulating the attic



9 After opening the roof edge, verify proper clearance to combustibles and inspect vent connections

**Manufactured Home - Attic Insulation Precheck**

Project:

<input type="checkbox"/>	N/A	PREPARATION
<input type="checkbox"/>	<input type="checkbox"/>	<b>1</b> All combustion appliance venting and flues maintain clearance to combustibles, unless zero clearance flue is in place
<input type="checkbox"/>	<input type="checkbox"/>	<b>2</b> All ventilation systems maintain a continuous connection and terminate to the outdoors
<input type="checkbox"/>	<input type="checkbox"/>	<b>3</b> All plumbing stacks are terminated to the outdoors
<input type="checkbox"/>	<input type="checkbox"/>	<b>4</b> Non-IC rated light fixtures are replaced with air-tight IC rated fixtures
<input type="checkbox"/>	<input type="checkbox"/>	<b>5</b> All ceiling-plane air sealing is complete, including marriage line, passive jumper ducts, and skylights
<input type="checkbox"/>	<input type="checkbox"/>	<b>6</b> All roof, attic, and ceiling assemblies are structurally sound
<input type="checkbox"/>	<input type="checkbox"/>	<b>7</b> Dishing and pooling issues of the roof that allow standing water are addressed
<input type="checkbox"/>	<input type="checkbox"/>	<b>8</b> All known roof leaks are repaired

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WA State Department of Commerce

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## 4.1003.8b - Attic Access via Roofside Lift

### Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

Fasteners will be removed from the J channel and the roof edge on the most easily accessible side of the house

Roof will be separated from the heel plate and siding. Roof will be lifted and propped to accommodate fill tube

Length of opening will be enough to allow ease of access and reattachment while minimizing potential damage from high winds

If subsheathing is present, access will be gained through subsheathing

Attic will be visually inspected for the location of existing insulation, obstructions, hazards, and construction type

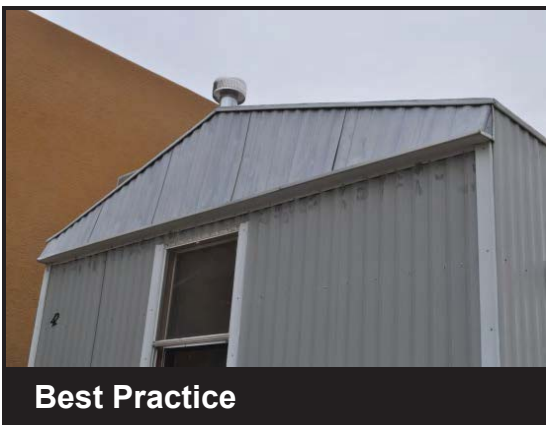
### Objective(s):

Create access to the full attic cavity

Protect roof from wind damage during installation

Ensure ease of roof reattachment

Determine insulation installation technique



**Best Practice**

Pitched, bowed, and vaulted roofs are good candidates for insulation via roof side lift



**Best Practice**

Insulation can be installed without disturbing the interior environment

**Tools:**

1. Pry bar
2. Drill
3. Utility knife
4. Pliers

**Materials:**

1. Wood blocks

## 4.1003.8b - Attic Access via Roofside Lift



Ensure a safe work environment by setting up scaffolding. Work in manageable sections



Remove fasteners from the J-channel



Cut through putty tape and pry J-channel away from roof seam



Work in manageable sections to minimize roof damage. One section of J-channel is a long enough area



Remove staples as necessary to lift roof and inspect underneath



Place blocks to lift roof and enable inspection of roof cavity for obstructions and other concerns



Work in small sections to minimize flexing of roof and risk of wind damage



Once visual inspection has shown roof cavity to be viable, begin blowing insulation

## 4.1003.8d - Fiberglass Blown Insulation Installation via Roofside Lift

### Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

Insulation will be installed to a density of 1.5 to 1.6 pounds per cubic foot

Using fill tube, 100% of each cavity will be filled to a consistent density

Fill tube will be inserted within 6" of the end of each attic cavity

Insulation will be installed into the void of the attic cavity:

- If existing insulation is roof-mounted, insulation will be blown below
- If existing insulation is ceiling-mounted, insulation will be blown above
- If existing insulation is mounted at both locations, insulation will be blown in between

Avoid overfilling of roof edges and above attic trusses

Flame spread and smoke-developed index for insulation will be a flame spread rating of 25 or less and a smoke development rating of 450 or less when tested in accordance with ASTM E84

### Objective(s):

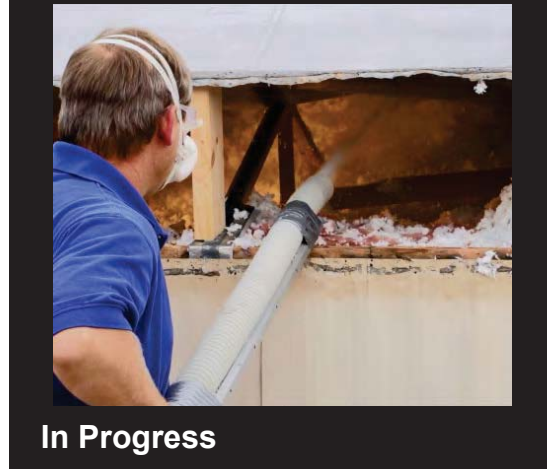
Fill entire attic cavity to the prescribed R-value to reduce air infiltration

Avoid clogging of the cavity and the fill tube

Prevent damage to the ceiling

Allow roof to be returned to original position

Fire safety will be maintained



## 4.1003.8d - Fiberglass Blown Insulation Installation via Roofside Lift



If insulation is roof mounted, blow below it.



If insulation is ceiling mounted, blow above it.



If insulation is mounted at both the ceiling and the roof, blow between it.



Insulation meets ASTM E 84.

## 4.1003.8e - Roof Reattachment via Roofside Lift

### Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

If existing J channel is damaged, it will be replaced

Existing sealant will be removed from the roof edge and J channel

At a minimum, new sealant will be reinstalled at the original location

Roof and J channel will be fastened to the original location with new screws

All seams, edges, and penetrations will be sealed as necessary

### Objective(s):

Prepare roof edge and J channel for reattachment

Reattach roof edge and J channel without leaks



 Before

If salvageable, clean J-channel before reinstallation



 After

Attach J-channel using old holes and new fasteners

### Tools:

1. Drill
2. Utility knife
3. Snips

### Materials:

1. Fasteners
2. J-channel
3. Putty tape

## 4.1003.8e - Roof Reattachment via Roofside Lift



1  
If J-channel is salvageable, clean thoroughly before applying putty tape



2  
Apply putty tape to new or reused J-channel to seal roof seam



3  
Using new fasteners, attach J-channel along roof seam and seal as necessary

## 4.1003.8f - Verification of Details via Roofside Lift

### Desired Outcome:

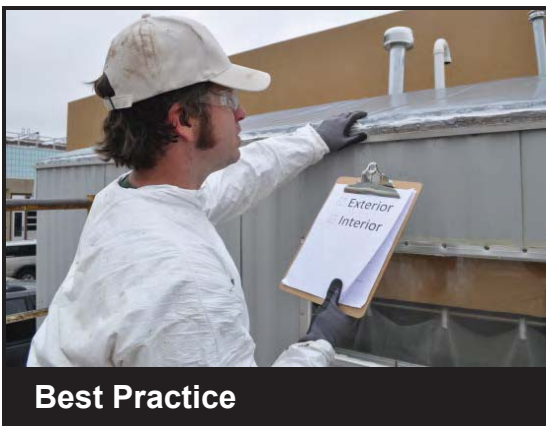
Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

Installation process will be considered complete when installer has verified that damage has not occurred to the roof or ceiling assemblies during the installation process

### Objective(s):

Verify the integrity of the house has been maintained



**Best Practice**

Exterior should be inspected to verify that roof has not been damaged



**Best Practice**

Interior ceiling should also be inspected to make sure that no damage was incurred

## 4.1003.9a - Attic, Ceiling, and Roof Verification via Exterior Access from Top of Roof

### Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

All combustion appliance flues will be terminated to the outdoors and terminations will maintain proper clearance above snow loads

A distance no less than 2" will be maintained between any combustion appliance flue and combustible materials, unless zero clearance flue is in place

All ventilation systems will maintain a continuous connection and terminate to the outdoors

All broken mushroom vents will be replaced or removed and sealed

All plumbing stacks will be terminated to the outdoors

Non-IC rated light fixtures will be replaced with airtight IC-rated fixtures or air-tight damming will be installed around existing Non IC-rated fixture when access allows

All recessed lights will be labeled as having an air leakage rate not more than 2.0 CFM when tested in accordance with ASTM E 283 at a 75 pascals pressure differential

All obvious ceiling penetrations will be sealed

The space between combustion appliance flues and the ceiling will be sealed with fire-rated materials

All roof, attic, and ceiling assemblies will be structurally sound:

- Loose ceiling panels will be secured
- Temporary ceiling bracing will be recommended during the insulation installation process

Dishing and pooling issues that allow standing water will be addressed

All known roof water leaks will be repaired before installing installation

### Objective(s):

Ensure occupant and worker safety

Verify attic space is ready to insulate

Ensure structural integrity of the roof and ceiling assembly

Prevent intrusion of bulk moisture

Prevent damage while installing insulation



**Before**

Roof leak, missing cap on vent



**After**

Properly connected and sealed roof vent

**Tools:**

1. 2-1/2" hole saw
2. Power drill
3. Borescope
4. Inspection mirror
5. Flashlight

**Materials:**

1. Material requirements will vary based on conditions
2. Drywall or paneling
3. IC/Airtight recessed lights
4. Fire caulk
5. Vent terminations
6. Silicone caulk
7. Galvanized sheet metal and screws
8. Roof cement
9. Temporary ceiling bracing

Inspect and correct each of the specified items: flues terminated to outside, 2" clearance to combustibles from flues, ventilation ducts terminated outdoors, non-airtight, non-IC rated recessed lighting replaced with airtight, IC-rated recessed units or air sealed from above, broken mushroom vents replaced or removed, plumbing vents terminated outdoors, ceiling penetrations sealed, structural defects in roof, attic, and ceiling assemblies corrected, ponds on roof remedied, and all roof leaks repaired.

## 4.1003.9a - Attic, Ceiling, and Roof Verification via Exterior Access from Top of Roof



1 Inspect roof for evidence of water pooling, leaks, or damage. Verify proper vent terminations



2 Inspect all patches and repairs, and correct deficiencies if necessary



3 Verify presence of rain caps on all vents



4 Inspect ceiling for weakness, leaks, clearance to combustibles, loose panels, and penetrations



5 Verify at least 2" clearance to combustibles, unless flue is designed for zero clearance. Repair if needed



6 Repair and refasten sagging or unsecured ceiling panels. Caulk and seal seams to prevent insulation spilling into house



7 Use temporary supports to avoid ceiling collapse during insulation install

## 4.1003.9b - Attic Access via Exterior Access from Top of Roof

### Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

Access to the attic cavity will be created using one of these methods:

- Drilling
- Cutting
- Continuous slicing along the center line (at the highest point of the roof )

Access location will be placed to allow for consistent and uniform coverage of installed insulation throughout the attic assembly

There will be, at a minimum, one opening between each roof truss

Openings will be large enough to accommodate the chosen fill tube

If subsheathing is present, access will be gained through subsheathing

Attic will be visually inspected for the location of existing insulation, wiring, flues, obstructions, hazards, and construction type

### Objective(s):

Create access to the full attic cavity

Maintain the integrity of the roof truss

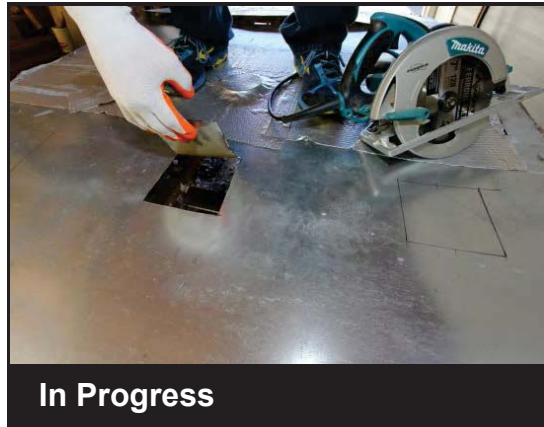
Protect roof from wind damage during installation

Determine technique for installing insulation



### In Progress

Manufactured home attic cavity accessed by cutting through roof.



### In Progress

Manufactured home attic cavity accessed by cutting through roof.

#### Tools:

1. 7-1/4" circular saw
2. Electric drill
3. Carbide-tipped hole saw bits
4. Insulation blowing machine
5. 10 feet long 2" PVC pipe, or 8 foot 2" flexible blow hose
6. 4-1/2" or 7" angle grinder with flexible sanding wheels
7. Tape measure and chalk lines

#### Materials:

1. Abrasive or carbide-toothed cutting wheels, or other cutting tools
2. Galvanized steel roofing pieces
3. Self-tapping sheet metal screws
4. Fiberglass mesh
5. Elastomeric roof coating
6. For gable access: appropriately sized soffit vent cover screens for hiding siding patches
7. Siliconized exterior caulk

**Gable end attic access:** when the manufactured home has partial vaulted ceilings or a compromised roof, access may be gained through the gable ends for the flat ceilings. Gable end access requires patching the siding with sheet metal, siliconized caulk, and optional vent cover to conceal patch.

Always use hand protection when working with metal edges and/or sharp tools.

## 4.1003.9b - Attic Access via Exterior Access from Top of Roof



Determine and mark truss locations on roof, and choose method of access. Avoid drilling or sawing into trusses



Cut a hole into each truss cavity, big enough to inspect the opening and admit the fill tube



Regardless of access method, visually inspect attic for existing insulation, wiring, flues, obstructions, and hazards



Another option: cut the roof open along the highest point from end to end. Make crosswise cuts at each end if needed



Locate the ceiling level and truss framing prior to drilling through gable siding.

## 4.1003.9d - Fiberglass Blown Insulation Installation via Exterior Access from Top of Roof

### Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

Insulation will be installed to a density of 1.5 to 1.6 pounds per cubic foot

Using fill tube, 100% of each cavity will be filled to a consistent density

Fill tube will be inserted within 6" of the end of each attic cavity

Insulation will be installed into the void of the attic cavity:

- If existing insulation is roof-mounted, insulation will be blown below
- If existing insulation is ceiling-mounted, insulation will be blown above
- If existing insulation is mounted at both locations, insulation will be blown in between

Insulation will be filled no higher than the top of the truss

Flame spread and smoke-developed index for insulation will be a flame spread rating of 25 or less and a smoke development rating of 450 or less when tested in accordance with ASTM E84

### Objective(s):

Fill entire attic cavity to the prescribed R-value to reduce air infiltration

Avoid clogging of the cavity and the fill tube

Prevent damage to the ceiling

Allow roof to be returned to original position

Fire safety will be maintained



**In Progress**

Always wear PPE appropriate to the work environment and job at hand.

### 4.1003.9d - Fiberglass Blown insulation installation via Exterior Acces From Top of Roof



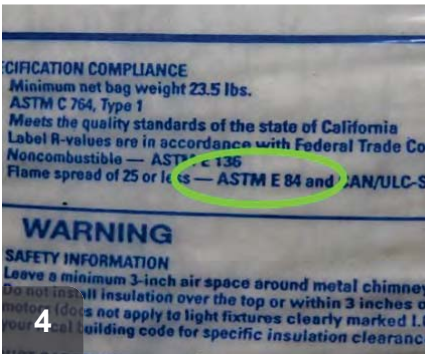
1  
If insulation is roof mounted, blow below it.



2  
If insulation is ceiling mounted, blow above it.



3  
If insulation is mounted at both the ceiling and the roof, blow between it.



4  
Insulation meets ASTM E 84.

## 4.1003.9e - Patching and Sealing Openings via Exterior Access from Top of Roof

### Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

If the roof is sliced:

- A solid metal ridge cap will be centered over the slice
- A flexible and durable sealant will be sandwiched between the roof and the ridge cap
- Screws will be installed to prevent wrinkles and create a permanent seal
- Screws will not go into any wood framing
- A durable and flexible final coating will be applied over the screws and edge of the ridge cap to create a continuous seal between the roof and the perimeter of the ridge cap

For holes that are drilled or cut, the initial patch will be applied using the following procedure:

- At least 6" of surface surrounding the opening will be cleaned before patch is installed
- Sealant will be continuous and applied in between the patch and the roof
- Sealant will be an all-weather adhesive that is flexible and durable

If a metal patch is used:

- Patch will overlap the opening by 2" on all sides
- Gauge will be equal to or greater than the roof material
- Fasteners will be installed to prevent wrinkles and create a permanent seal
- If a plug is used, it will be flanged and have a tight fit
- Screws will not go into any wood framing

A durable and flexible 45 mil adhesive patch will be applied in accordance to manufacturer specifications over the initial patch and will have at a minimum:

- Tear strength of 640g
- Elongation of 380%
- Application temperature no lower than 55°F and no greater than 110°F
- Services temperature no less than -25°F and no greater than 150°F
- Adhesive patch will overlap the initial patch by 2" on all sides
- A durable and flexible final coating will be applied over the adhesive patch to create a continuous seal between the roof and the perimeter of the patch
- All remaining seams, edges, and penetrations will be sealed as necessary

### Objective(s):

Effectively patch and seal all openings

Create a durable patch that will prevent roof leaks



**In Progress**

Rough cut hole that will need to be sealed.



**In Progress**

Placing sealant around the exposed edges of the roof patch ensures a watertight seal.

**Tools:**

1. Roller
2. Self adhering patch
3. sheet metal
4. 6" duct cap(to match 6" hole)
5. heat gun
6. drill

## 4.1003.9e - Patching and Sealing Openings via Exterior Access from Top of Roof



Insert 6" plug and seal around the perimeter of the opening.



Firmly push the plug into place, until it is flush with the roof surface.



Use a 10"x10" sheet metal patch to mark the center of the hole.



Apply sealant to the underside of the sheet metal patch.



Secure the metal patch to the roof being sure to place mechanical fasteners through the sealant.



Apply a 14"x14" self adhering roof patch on top of the sheet metal patch.



Use a heat gun to make the adhesive pliable to get the best possible seal.



Forcefully roll the patch into place, starting from the center and working toward the edge.

## 4.1003.9f - Verification of Details via Exterior Access from Top of Roof

### Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

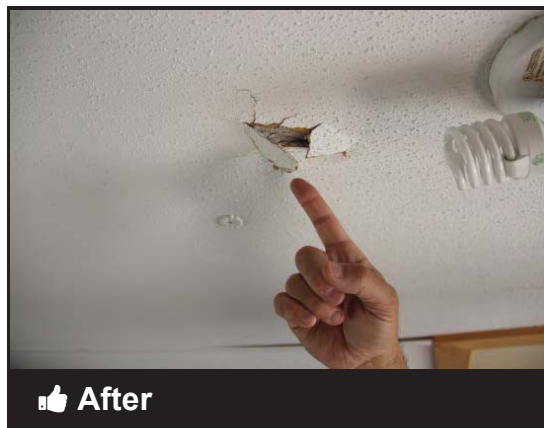
Installation process will be considered complete when installer has verified that damage has not occurred to the roof or ceiling assemblies during the installation process

### Objective(s):

Verify the integrity of the house has been maintained



Verify that no damage has been done by the workers. When in doubt, verify with photo documentation.



Document and repair any damage the workers caused.

### Tools:

1. IR camera

## 4.1003.10a - Attic, Ceiling, and Roof Verification via Interior Access Through the Ceiling

### Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

All combustion appliance flues will be terminated to the exterior of the house and terminations will maintain proper clearance above snow loads

A distance no less than 2" will be maintained between any combustion appliance flue and combustible materials, unless zero clearance flue is in place

All ventilation systems will maintain a continuous connection and terminate to the outdoors

All broken mushroom vents will be replaced or removed and sealed

All plumbing stacks will be terminated to the outdoors

Non-IC rated light fixtures will be replaced with airtight IC-rated fixtures, if feasible and only when installed measures will compromise the fire rating of the fixture

All recessed lights will be labeled as having an air leakage rate no more than 2.0 CFM when tested in accordance with ASTM E 283 at a 75 pascals pressure differential

All obvious ceiling penetrations will be sealed

The space between combustion appliance flues and the ceiling will be sealed with fire-rated materials

All roof, attic, and ceiling assemblies will be structurally sound:

- Loose ceiling panels will be secured
- Temporary ceiling bracing will be recommended while installing installation

Dishing and pooling issues that allow standing water will be addressed

All known roof water leaks will be repaired before installing installation

### Objective(s):

Ensure occupant and worker safety

Verify attic space is ready to insulate

Ensure structural integrity of the roof and ceiling assembly

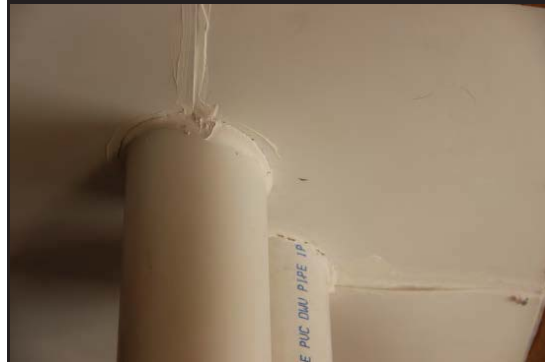
Prevent intrusion of bulk moisture

Prevent damage while installing insulation



**Best Practice**

The flue of a 90+ efficiency furnace terminates above the snow line and the roof penetrations have been sealed.



Flue penetrations have been sealed correctly from the interior.

## **4.1003.10a - Attic, Ceiling, and Roof Verification via Interior Access Through the Ceiling**



Plumbing stacks must be terminated to the outdoors.



Dishing and pooling issues must be addressed.



Mushroom vents must be replaced, or removed and sealed.



Proper clearance to combustibles will be maintained through the roof assembly.



Inspect ceiling for weakness, leaks, clearance to combustibles, loose panels, and penetrations.

## 4.1003.10b - Construction Prep via Interior Access Through the Ceiling

### Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

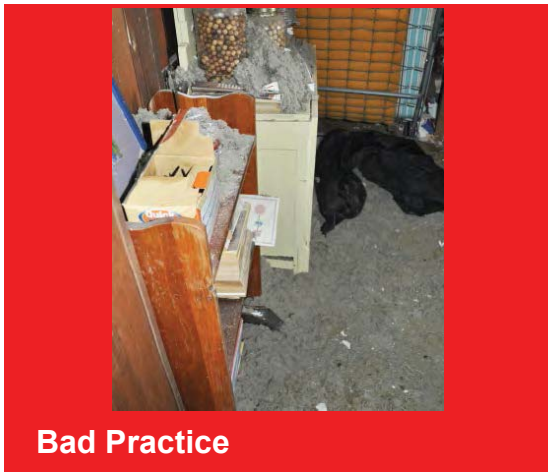
### Specification(s):

Special precautions will be taken to limit fiberglass and construction dust exposure to the occupant and occupant belongings

### Objective(s):

Protect occupant health and safety

Protect occupant belongings



Improperly prepared workspace with cellulose all over client belongings and bedroom



Worker has removed or covered occupant belongings. Be sure to ask permission before removing any client belongings

### Tools:

1. Utility knife

### Materials:

1. Plastic sheeting
2. Removable, low-residue tape

## **4.1003.10e - Fiberglass Blown Insulation Installation via Interior Access Through the Ceiling**

### **Desired Outcome:**

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### **Specification(s):**

Insulation will be installed to a density of 1.5 to 1.6 pounds per cubic foot

Using fill tube, 100% of each cavity will be filled to a consistent density

Fill tube will be inserted within 6" of the end of each attic cavity

Insulation will be installed into the void of the attic cavity:

- If existing insulation is roof-mounted, insulation will be blown below
- If existing insulation is ceiling-mounted, insulation will be blown above
- If existing insulation is mounted at both locations, insulation will be blown in between

Flame spread and smoke-developed index for insulation will be a flame spread rating of 25 or less and a smoke development rating of 450 or less when tested in accordance with ASTM E84

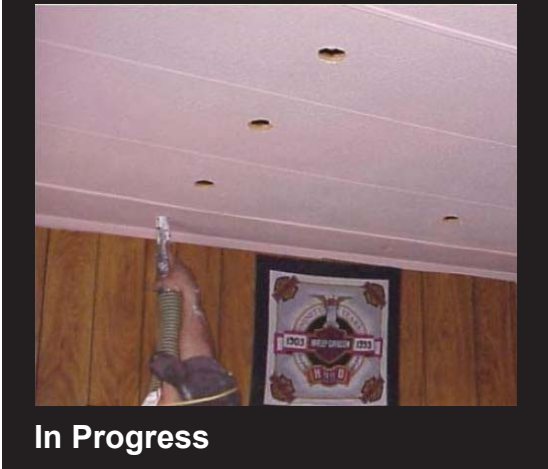
### **Objective(s):**

Fill entire attic cavity to the prescribed R-value to reduce air infiltration

Avoid clogging of the cavity and the fill tube

Prevent damage to the ceiling

Fire safety will be maintained



Attic insulation should be consistently installed in each cavity to the edge.

## 4.1003.10e - Fiberglass Blown Insulation Installation via Interior Access Through the Ceiling



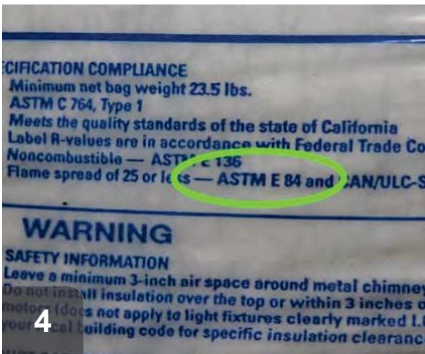
1  
If insulation is roof mounted, blow below it.



2  
If insulation is ceiling mounted, blow above it.



3  
If insulation is mounted at both the ceiling and the roof, blow between it.



4  
Insulation meets ASTM E 84.

## 4.1003.10f - Patching and Sealing Holes via Interior Access Through the Ceiling

### Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

Holes will be plugged or covered and sealed to be aesthetically pleasing

If existing trim was removed, it will be reinstalled

### Objective(s):

Create an airtight seal

Create a visually acceptable ceiling finish



Holes should be effectively sealed, as well as aesthetically pleasing.

### Tools:

1. color matched plug

### Materials:

1. color matched plug

## 4.1003.10g - Verification of Details via Interior Access Through the Ceiling

### Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

Installation process will be considered complete when installer has verified that damage has not occurred to the roof or ceiling assemblies during the installation process

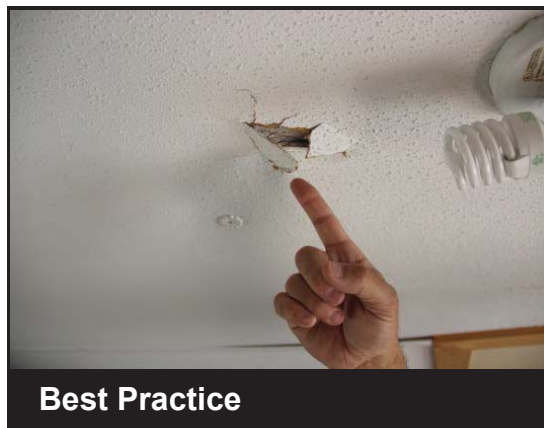
### Objective(s):

Verify the integrity of the house has been maintained



**In Progress**

Verify that no damage has been done by the workers. When in doubt, verify with photo documentation.



**Best Practice**

Document and repair any damage the workers caused.

## 3.1101.3c - Marriage Line Air Sealing

### Desired Outcome:

Penetrations sealed to minimize air leakage and moisture movement between unconditioned and conditioned space; all repairs to maintain structural integrity

### Specification(s):

All accessible holes and penetrations at marriage lines will be sealed continuously at end walls, floors, and ceiling

Backing or infill will be provided at the marriage line as needed

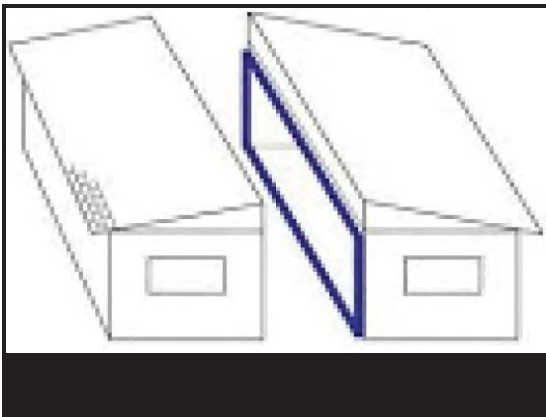
All remaining gaps will be sealed with an approved material

### Objective(s):

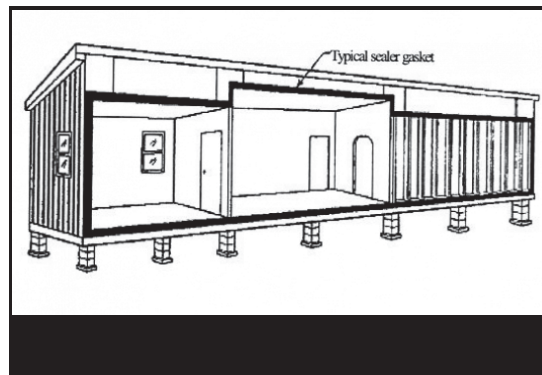
Minimize air leakage

Maintain durability

Ensure sealant is effective and durable



The marriage line is a common location of air leakage in a mobile home building shell.



Identify leaks in marriage line using a blower door

**Tools:**

1. Reusable foam sealant gun
2. Caulking gun
3. Utility knife
4. Tape measure
5. Screw gun
6. Hammer
7. Prybar
8. Blower door
9. Chemical smoke dispenser

**Materials:**

1. Caulk
2. Foam sealant
3. Foam board
4. Screws

The marriage line is air sealed from inside the home and from underneath. Use a blower door and chemical smoke to pinpoint air leakage locations. You may need to remove interior trim to determine what type of sealing is needed at the marriage line. Some double wide manufactured homes are constructed with a compressed open-cell polyurethane foam sealing strip with excellent air sealing properties and will need little or no additional work. Other construction methods may feature fiberglass or other ineffective air sealing measures and require extensive caulking and foaming to reduce air infiltration.

## 3.1101.3c - Marriage Line Air Sealing



Identify leaks in marriage line using a blower door and smoke



Foam, caulk, and seal leaks between halves of double wide manufactured homes



Foam sealant has been installed to air seal the floor plane marriage line, accessed from below.



Marriage line air sealing of the ceiling plane is accessed from inside the home.

## 3.1301.2d - Floor Repair

### Desired Outcome:

Penetrations sealed to minimize air leakage and moisture movement between unconditioned and conditioned space; all repairs will maintain structural integrity

### Specification(s):

Floor repair material will meet or exceed strength of existing floor material

Repair will span from joist to joist and blocking added as needed to support floor

Patches smaller than 144 square inches will not require repairs from joist to joist

Floor repair material will be glued, fastened, and air sealed

### Objective(s):

Ensure floor is structurally sound

Minimize air leakage



Remove floor coverings from damaged area



Completed floor repair

**Tools:**

1. Circular saw
2. Reciprocating saw
3. Caulking gun
4. Cordless driver/drill
5. Framing square
6. Speed square
7. Utility knife
8. Sawhorses
9. Clamps
10. Jig saw or keyhole saw
11. Paddle bits to drill starter holes in floor

**Materials:**

1. 5/8" or 3/4" oriented strand board or plywood subflooring
2. Polyurethane caulk
3. Construction adhesive
4. 2" deck screws
5. 3" deck screws
6. 8-penny galvanized ring shank or spiral shank nails
7. 16-penny galvanized ring shank or spiral shank nails
8. 2X4, or 2X6 blocking material for nailers
9. Air sealing foam (one- or two-part SPF)
10. Belly repair tape

Paddle bits may be used to drill starter holes at the corners of the area to be patched. Cut the new patch 1/4" shorter than the hole in both length and width to allow room for expansion and contraction. Make sure to cut the patch so that the strength axis is perpendicular to the joists (the strong direction in plywood and OSB is parallel to the 8' length).

### 3.1301.2d - Floor Repair



1 Mark the joist locations on either side of the damaged area



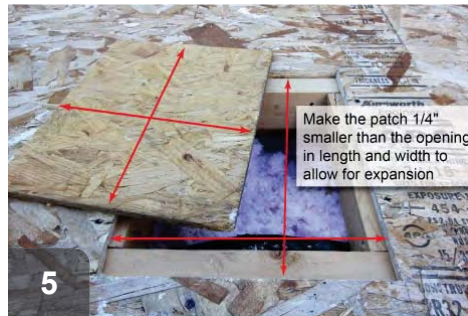
2 Cut out damaged area even with the inside edges of the floor joists



3 Cut four 2X4 blocks to support the patch



4 Install nailers flat against the joists. Finish by toenailing or screwing 2X4s between the joists



5 Make the patch 1/4" smaller than the opening in length and width to allow for expansion.



6 Apply subfloor adhesive to nailers



7 Fasten with 2" deck screws

## 3.1602.8d - Repair Work Access

### Desired Outcome:

Deliver all air from air handler to the trunk duct without leakage or restriction

### Specification(s):

Point of access options include:

Option 1: Through the trunk duct

- Repair and seal access hole in the trunk duct
- Install insulation
- Repair belly/bottom liner

Option 2: Remove crossover duct

- Reattach crossover duct
- Seal and insulate crossover duct
- Repair belly/bottom liner

Option 3: Remove air handler

- Install new gasket, if necessary
- Mechanically attach furnace to the structure
- Reconnect utilities
- Replace and seal panels

Option 4: Through the furnace panel

- Replace and seal panels

### Objective(s):

Repair work access

Prevent condensation

Minimize heat loss and heat gain from plenum



👍 After

Various methods can be employed, but the key is to seal the furnace to trunk duct connection

#### Tools:

1. Utility knife
2. Saw
3. Prybar
4. Screw gun
5. Hammer
6. Drill
7. Saw
8. Disposable brushes

#### Materials:

1. Belly repair tape
2. Mastic duct sealant
3. Fiberglass mesh tape
4. Insulation
5. Air handler gasket
6. Sheet metal patch, if trunk is cut into

1. Choose the least invasive and labor-intensive method that will allow full access for sealing.
2. Patch trunk using sheet metal patch, fastened mechanically and sealed with mastic.
3. Always wear hand protection when working with sharp objects.



For electric furnaces, follow lockout/tag-out procedures to break circuits that supply furnace with electricity.



Cut belly to expose duct trunk. Use a utility knife to cut access under furnace plenum



Create an opening large enough to completely seal the plenum to the trunk line.



Using mastic and mesh tape, fully seal the furnace to the trunk line. Patch opening in duct with sheet metal and seal. Repair and seal the access holes in duct and belly.



Removing the crossover duct may provide access to the plenum. Replace and seal the crossover duct after sealing plenum



Remove the furnace panel. If the plenum to trunk connection is accessible here, complete sealing from this point



Plenum to duct trunk connection coated with mastic sealant



As with all duct sealing and repair, confirm success with pressure diagnostics.

## 3.1602.9b - Crossover Ducts

### Desired Outcome:

Deliver all air from trunk to trunk without leakage or restriction

### Specification(s):

Crossover ducts will be added, rebuilt, or repaired when found to be disconnected, damaged, or otherwise inadequately delivering supply air.

Assemble crossover ducts as follows:

- Constructed of rigid, 26 gauge metal ducting
- Mechanically fastened at all junctions
- Sealed using UL-listed sealant that is durable and structurally sound
- Insulated to a minimum R-8 and equipped with a vapor retarder

Whenever possible, rigid elbow or equivalent will be installed in crawl space crossover ducts

Floor insulation will be in contact with the outer liner of the crossover duct

Crossover duct vapor retarder will be sealed to the bottom liner (e.g., belly fabric)

New flex duct installation will be insulated to a minimum of R-8

When feasible, 26-gauge hard duct should be installed

If a new crossover is required, it must be insulated to at least R-8 and be air sealed

### Objective(s):

Ensure lasting durable connections

Minimize air leakage and heat transfer

Maintain duct diameter around the turns

Maximize air flow and distribution



**Before**

Poorly performing crossover duct: poor materials, excess length and contacting ground.



**After**

Crossover duct of rigid material, sealed, insulated and supported to specification.

### Tools:

1. Drill
2. Metal snips
3. Metal crimper

### Materials:

1. Rigid ducting: elbows, straight sections
2. Sheet metal screws
3. Mastic or other appropriate sealant
4. Vinyl-faced fiberglass insulation, R-8 or greater.
5. Nylon twine or wire
6. Rigid foam
7. Duct support materials

1. Crossover duct support shall comply with 3.1601.3a - *Support*
2. New crossover installation using flexduct is allowable only when rigid ducting is not feasible. A minimum of R-8 is still required for the crossover duct.

## 3.1602.9b - Flexible Crossover Duct Connections



1 Attach elbow duct and orient in correct direction to minimize duct run



2 Fasten elbow in place with at least three evenly-spaced fasteners



3 Apply mastic at all metal-to-metal connections



4 Apply mastic to all elbow joints and flange



5 Insulate and support crossover duct



6 When clearance requires crossover to contact ground, crossover shall rest on vapor barrier and closed cell rigid foam.



7 All duct sealing and repair will be confirmed with pressure diagnostics.

## 4.1302.1b - Preparation

**Desired Outcome:**

Belly floor cavity ready for insulation

**Specification(s):**

Where bottom board/rodent barrier is missing or damaged and accessible, the following will be ensured:

- Duct sealing completed
- Gas, water, and electrical lines secured at least every 4' to a floor joist or framing member
- Water line will be located on the warm side of the insulation; if not, the water lines will be insulated appropriately
- No water or gas leaks are present
- Waste lines are sloped to 1/4" per foot
- Bottom board/rodent barrier is sound/strong enough to support insulation

When bottom board is intact, the following will be ensured:

- Holes and penetrations in the bottom board and decking sealed
- Duct sealing completed
- No water or gas leaks present
- Bottom board is sound/strong enough to support insulation
- Water lines are secured to the floor joists/warm side of the insulation; if not, the water lines will be insulated appropriately

Problems will be corrected before floor cavity insulation work begins

**Objective(s):**

Ensure problems are corrected before floor cavity insulation work begins

Keep pipes from freezing



**Before**

Damaged rodent barrier ("belly") must be patched prior to insulating, or to reduce air flow if not insulating.



**After**

Belly with patching complete.

### Tools:

1. Stitch stapler
2. Pneumatic stapler
3. drill motor

### Materials:

1. Belly patch material (house wrap or similar)
2. Staples
3. Screws
4. Adhesive or suitable tape
5. Lath or dimensional lumber

1. The belly board (flexible rodent-barrier) must be complete and intact in areas where insulation is blown-in. The rodent barrier shall be supported as required to avoid sagging.
2. Holes in the rodent barrier shall be patched with like or similar materials that are stitch stapled or mechanically fastened and glued to the existing rodent barrier with adhesive, mastic, or caulk.
3. Stitch staples shall be at a minimum size 9/16, type galvanized or stainless, and gauge 4M. Patches must be sealed with caulk, glue, mastic, or adhesive (peel & seal) and have a minimum number of 4 staples per patch.
4. Holes in the rim joist used to install insulation in the cavity between the belly board and sub-floor shall be plugged with wooden plugs glued in place with an exterior-rated sealant.

## 4.1302.1b - Preparation



1  
Belly damage: rodent barrier and insulation are damaged, revealing a main supply duct known as a trunk.



2  
Mobile home duct systems (plenum, trunk terminations) should be sealed from below prior to patching the belly.



3  
Workers install new material where rodent barrier is missing.



4  
Maintain all combustion air intake openings when patching belly material.



5  
Pin up sagging belly material to prevent installing excessive amounts of insulation material.

**Manufactured Home - Underfloor Insulation Precheck**

Project:

<input type="checkbox"/>	N/A	PREPARATION
<input type="checkbox"/>	<input type="checkbox"/>	<b>1</b> All plumbing supply leaks are repaired
<input type="checkbox"/>	<input type="checkbox"/>	<b>2</b> All plumbing drain leaks are repaired
<input type="checkbox"/>	<input type="checkbox"/>	<b>3</b> All forced air supply ducts are sealed, including trunk-lines and any jumper ducts
<input type="checkbox"/>	<input type="checkbox"/>	<b>4</b> Furnace plenum connection to trunk-line duct is sealed
<input type="checkbox"/>	<input type="checkbox"/>	<b>5</b> Cross over duct is installed or repaired to specification (see Fied Guide 3.1602.9b - Crossover ducts)
<input type="checkbox"/>	<input type="checkbox"/>	<b>6</b> All floor-plain air sealing is complete, including marriage line, hole under the tub, plumbing penetrations, and electrical penetrations
<input type="checkbox"/>	<input type="checkbox"/>	<b>7</b> All combustion air inlets that are ducted into crawlspace are maintained (they could be for wood stove, pellet stove, water heater, furnace)
<input type="checkbox"/>	<input type="checkbox"/>	<b>8</b> All belly repairs and patching are complete
<input type="checkbox"/>	<input type="checkbox"/>	<b>9</b> Belly material is pinned up against floor joists where possible in odrer to reduce sag and amount of insulation needed

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WA State Department of Commerce

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## 4.1303.1c - Insulate Floors

### Desired Outcome:

Consistent thermal boundary between conditioned and unconditioned space that reduces heat flow

### Specification(s):

Each cavity will be insulated to specified R-value and density

The number of bags installed will be confirmed and will match the number required on the coverage chart

### Objective(s):

Eliminate voids and settling

### Tools:

1. Utility knife
2. Stitch stapler
3. Insulation machine and loose fill gear, flexible belly hose

### Materials:

1. Staples
2. Tape compatible with rodent barrier material
3. Fiberglass insulation

## 4.1303.1c - Insulate Floors



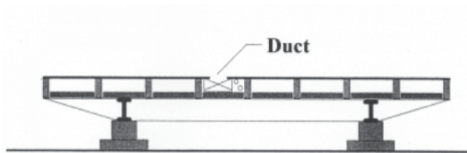
1 Holes are cut through rodent barrier (belly material) to insert insulation blow hose.



2 Loose fill insulation is blown into mobile home belly cavity.

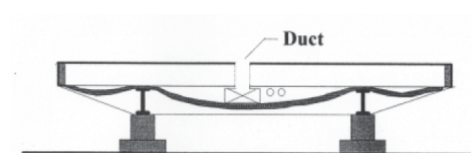


3 Blow holes in belly material patched.



4 Duct Location - Lengthwise Joists

Cross section of belly cavity viewed from end of mobile home with lengthwise joists. Note duct location.



5 Duct Location - Crosswise Joists

Cross section of belly cavity viewed from end of mobile home with crosswise joists. Note duct location.



6 Belly cavity blown by drilling through rim joists.



7 Cut away view of belly cavity with joists running crosswise. Insulation blown through rim joist.



8 Cut away of belly cavity with joists running lengthwise. Insulation blown through rim joist.

## 4.1104.1a - Access Wall Cavities

### Desired Outcome:

Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

If skirting overlaps siding, skirting will be detached to allow access to the wall cavity

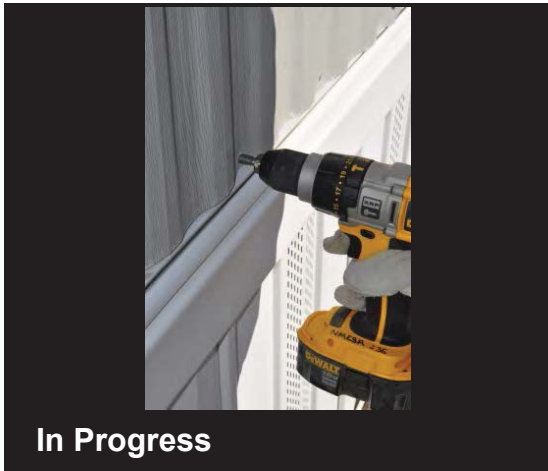
Fasteners will be removed from the bottom of the siding, working upward until the siding can be pulled away from the framing approximately 6" without damaging the siding

Temporary fasteners will be installed near the bottom of the siding panels at the seams to prevent separation

If a subsheathing is present under the siding, access through the subsheathing will be required

### Objective(s):

Gain access to the wall cavity without damaging or separating the siding



**In Progress**

Remove fasteners from along bottom and side seams to access wall cavity



**After**

Remove enough fasteners to create at least a 6in gap without damaging siding

### Tools:

1. Drill

## 4.1104.1a - Access Wall Cavities



1  
If skirting overlaps siding, remove skirting



2  
Temporarily fasten siding panels at joint to hold seam together



3  
Seam should remain together with temporary fastener

## 4.1104.1b - Exterior Wall Cavity Inspection

### Desired Outcome:

Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

Wall cavities will be inspected for moisture damage, pest locations, and integrity of the wiring, and holes to the interior

Siding will be repaired as necessary

Location of belt rails, obstructions, and existing insulation will be identified

All interior surfaces of exterior walls will be inspected for loose paneling joints, occupant wall hangings, location of switches and outlets, and other wall obstructions

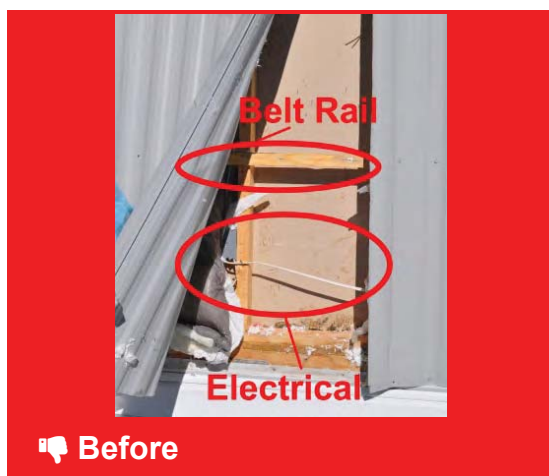
Objects will be removed from the interior surfaces of the walls being insulated

Interior paneling will be repaired as necessary

### Objective(s):

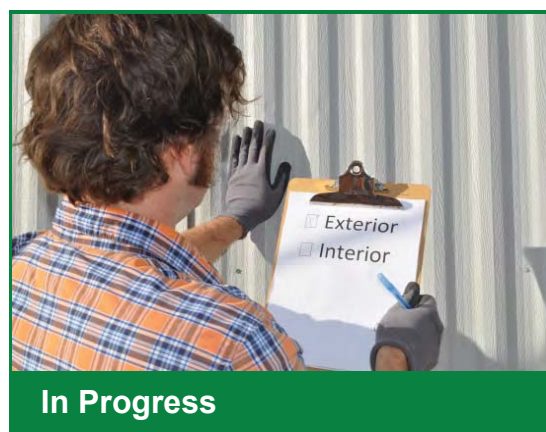
Prepare wall cavity for insulation

Prevent water leaks from occurring



**Before**

Take note of obstacles in the wall cavity, such as belt rails and electrical wiring



**In Progress**

Assess that holes in both exterior siding and interior walls have been patched before beginning installation

**Tools:**

1. Drill
2. Utility knife
3. Taping knife
4. Caulk gun

**Materials:**

1. Spackle
2. Metal siding patch
3. Caulk
4. Fasteners

## 4.1104.1b - Exterior Wall Cavity Inspection



Obstacles should be noted and planned for--insulation should be tucked behind belt rails



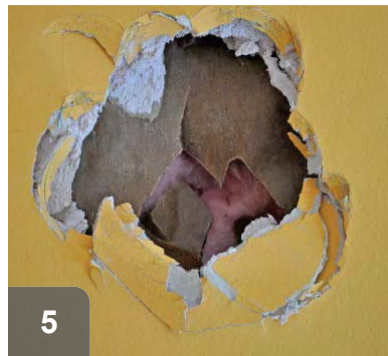
2 Holes in exterior siding should be patched



3 Apply sealant to back of patch to maintain air barrier



4 Ensure that patch is securely fastened and water-tight



5 Holes and penetrations in the interior wall should be patched as well



6 Verify that patches to both interior and exterior have been completed before beginning installation

## 4.1104.1c - Fiberglass Batt Installation Tool (Stuffer)

### Desired Outcome:

Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

A sheet of polycarbonate, such as Lexan, will be cut to the following specifications to create a stuffer tool:

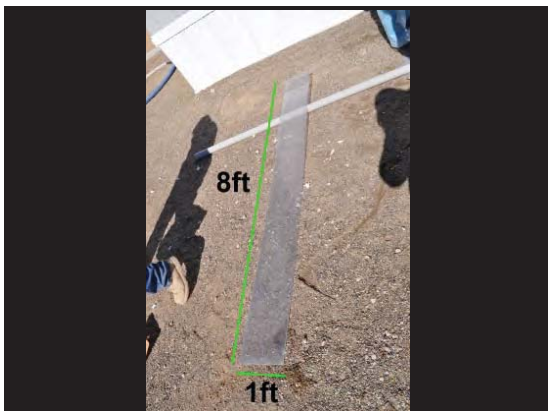
- Approximately 1' x 8' x 1/4" with a 5 degree bend 7' 1/2" from the bottom
- All corners of the Lexan (polycarbonate) will be rounded and all edges will be sanded

Other clear sheet plastics will not be used due to a tendency to shatter under stress

### Objective(s):

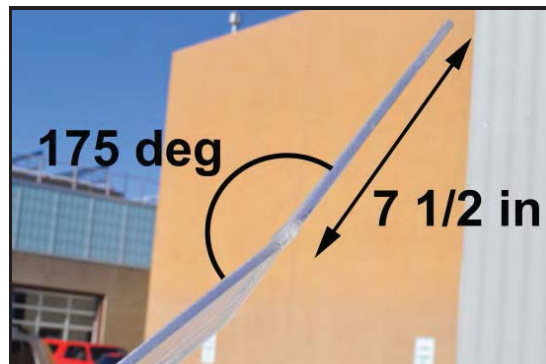
Create a tool to install a fiberglass batt into the cavity

Ensure worker safety



#### Best Practice

Insulation stuffing tool should be made of 1/4" polycarbonate, cut to 1' wide and 8' long



#### Best Practice

At one end, a bend of 5 degrees (175 degree supplement) should be made 7 1/2" from narrow edge

### Tools:

1. Tape measure
2. Table saw with fine-toothed blade
3. Sander
4. Heat gun
5. Clamp
6. Protractor
7. Heat-resistant gloves

### Materials:

1. Polycarbonate, like Lexan
2. Sandpaper

Most crews should have this tool in their supply. If one needs to be fabricated, find someone who has worked with polycarbonate before and ensure correct tool usage as well as proper PPE during fabrication.

## 4.1104.1d - Fiberglass Batt Installation

### Desired Outcome:

Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

Thickness of the batt will fill the void without deforming siding or damaging structure

Fiberglass batts will fill the cavity (e.g., batt may be cut approximately 1" longer to ensure proper fill and allow for lap at the top)

Flexible membrane will have an appropriate perm rating for the region

Flexible membrane will be cut 2" wider than the cavity and approximately 1' longer than the batt

Stuffer tool, membrane, and fiberglass batt will be aligned for installation

Stuffer tool will be used to install the fiberglass batt and membrane at the same time

Excess fiberglass batt and membrane vapor retarder extending below the cavity will be rolled and tucked into the cavity

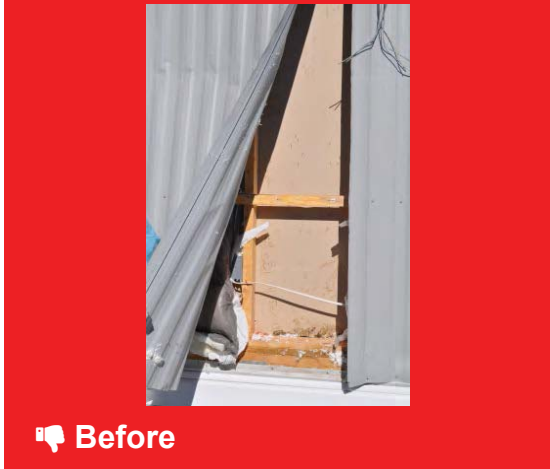
A poly-encased fiberglass batt may be used in place of the fiberglass batt and membrane assembly

The membrane will be installed in contact with the side of the wall that is compatible with the local climate zone

### Objective(s):

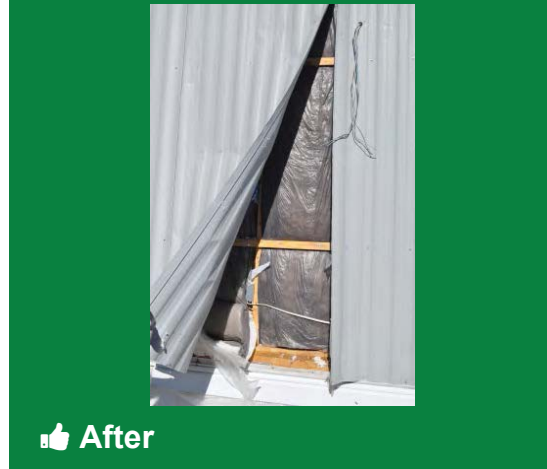
Maintain integrity of the batt

Aid in the installation process



**Before**

Uninsulated and underinsulated wall cavities can be filled from the exterior with fiberglass batts



**After**

Fiberglass batt should fill entire cavity without creating bulging in exterior paneling

**Tools:**

1. Tape measure
2. Utility knife

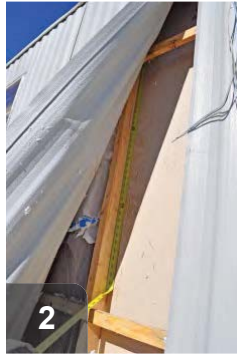
**Materials:**

1. Fiberglass batts, may be wrapped
2. Vapor barrier appropriate for region

## 4.1104.1d - Fiberglass Batt Installation



1  
Uninsulated wall cavity can be accessed from exterior of mobile home through paneling



2  
Measure length of cavity



3  
Measure depth of cavity



4  
Select appropriate batt thickness and R-value. Wrapped batts provide a built in vapor barrier



5  
Measure batt to length of cavity with extra for overlap from stuffing tool



6  
Lap cut batt over bent end of stuffing tool



7  
Beginning with lapped end, tuck batt under top belt rail and stuff batt up to top of cavity. Remove stuffing tool



8  
Tuck bottom of batt behind bottom belt rail. If longer than cavity, cut to within 1" longer, roll and tuck into cavity

## 4.1104.1f - Reattachment

### Desired Outcome:

Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

### Specification(s):

If skirting was removed, skirting will be reinstalled to shed water to the outside of the skirting

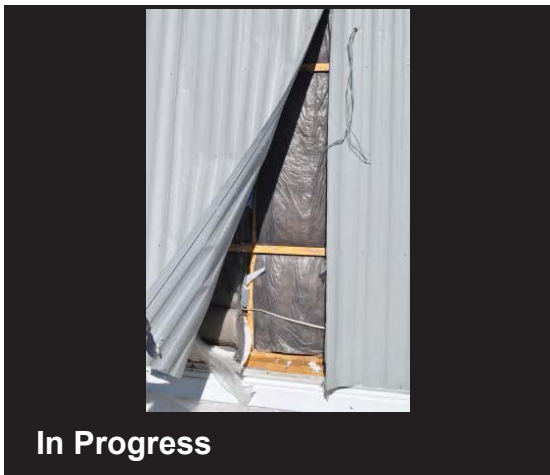
Siding will be reattached with new fasteners

Siding will be reattached without bulges or wrinkles

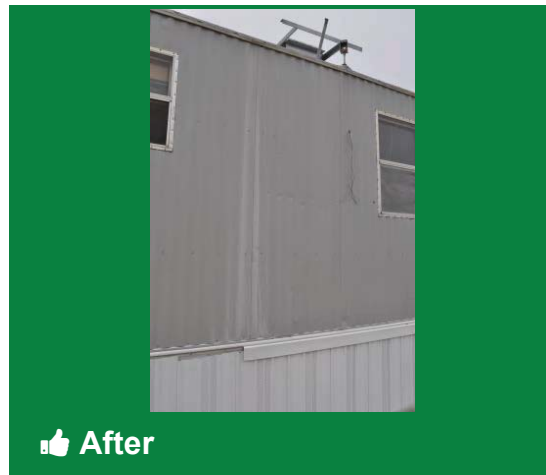
### Objective(s):

Ensure the integrity of the drainage plane

Return siding to existing conditions without damage



After wall cavities have been stuffed, paneling needs to be put back into place and refastened



Once work is finished, reattach siding and skirting, ensuring neither have been damaged

### Tools:

1. Drill

### Materials:

1. Fasteners

## 4.1104.1f - Reattachment



Using new fasteners, reattach paneling



Reinstall skirting, if necessary



Reattach trim, if necessary



Verify that siding and skirting have not been damaged and show no signs of bulging



<b>0</b>						
Client Name: _____						
<b>0</b>						
Address: _____						
<b>Pre Blower Door:</b>						
i.	Client Eligibility Date:					
ii.	Audit Date:					
iii.	Client Interview Performed?					Yes      No
iv.	Pollution Source Survey Completed?					Yes      No
v.	Contaminants present that would either prohibit blower door test completely or require pressurization test:					
vi.	Technician:					
vii.	Date:					
<b>CALCULATIONS</b>			Pre	In-Progress	Post	
1	Calculated total square footage of heated area					
2	Calculated volume of conditioned space					
<b>BASELINE CONDITIONS &amp; HOUSE TIGHTNESS - Blower door</b>			Pre	In-Progress	Post	
3	Primary heat source fuel type (example: nat. gas, electric, propane, wood)					
4	Windspeed MPH					
5	Outside temperature °F					
6	Blower door location					
7	Baseline without blower door on in pa (stack effect)					
8	Blower door configuration: O=open fan A=ring A B=ring B LF= low flow ring					
9	Total CFM50					
10	<b>ZONAL PRESSURES - Blower door</b>			Pre	In-Progress	Post
	ATTIC	WRT house				
	CRAWLSPACE	WRT house				
	GARAGE	WRT house				
	OTHER:	WRT house				
	OTHER:	WRT house				
	OTHER:	WRT house				
11	Location of existing ducts: A=inside B=outside C=inside/outside					
12	<b>12. Duct Pressure Test - Blower Door</b>					
13			<b>13. Room Pressure - HVAC fan only</b>		<b>Pressure Pan: House WRT Duct</b>	
	<b>Location</b>	<b>S/ Supply R/Return</b>	<b>Room WRT main body</b>		<b>Pre</b>	<b>In Progress</b>
			<b>Pre</b>	<b>Post</b>		<b>Post</b>
a.						
b.						
c.						
d.						
e.						
f.						
g.						
h.						
i.						
j.						
k.						
l.						
<b>TESTING AIRHANDLER (HVAC) EFFECTS: HVAC fan only</b>			Pre	In-Progress	Post	
14	<b>Dominant Duct Leak Test:</b> Main Body WRT outside (all interior doors open)					
15	<b>All Doors Closed Effect:</b> Main Body WRT outside (all interior doors closed)					
16	Duct location after Wx and Repairs: A=inside B=outside C=inside/outside					
17	Electric furnace heat rise test (supply°F–return°F) acceptable range:>40°to<70°					
18	Return house to pre test conditions (Check box when done)					<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
<b>NOTES/DOCUMENTATION:</b>						

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**Pressure Pan Tests**

In typical mobile home duct configurations, pre pressure pan tests help locate areas of significant leakage or disconnected duct work. After belly is filled with insulation, post pressure pan tests results may not be useful.

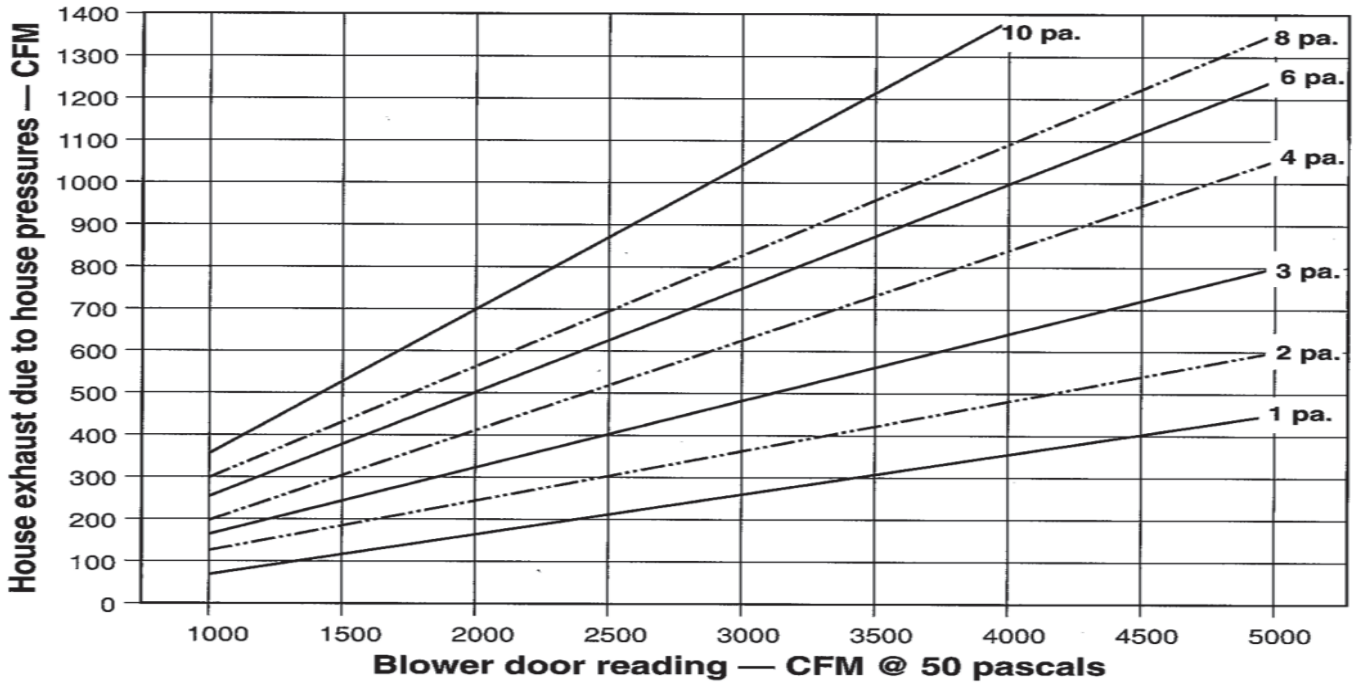
In site built homes with supply and return duct systems enclosed entirely within the thermal and pressure boundaries, pressure pan tests are not required.

**Dominant Duct Leak Test**

In typical mobile home duct configurations, dominant duct leak tests are especially useful. You can quantify the amount of duct leakage by using the Air Leakage Chart (aka Tooley Chart) if the return is isolated in the conditioned space and the supplies are isolated in the belly. No more than 100CFM of total supply duct leakage is recommended.

In site built homes with supply and return duct systems enclosed entirely within the thermal and pressure boundaries, dominant duct leak tests are not required.

**Air Leakage Chart**



Revised July 2012

## State of Washington, Weatherization Assistance Program

### Technical Support Document (TSD)

## Diagnostic Test Report

This document is intended to support in detail the Diagnostic Test Report. The Diagnostic Test Report must be filled out in detail for each completed project. You must document in the comments section of the Diagnostic Test Report any special circumstances or health and safety related concerns that might help someone understand the condition of the home (pre- and post-), as well as the concerns expressed by the occupants, or the agency concerns for the occupants safety at the time testing was performed.

The testing procedure outlined in this document is intended to be the minimum tests needed to understand the condition of the home.

### Pre Blower Door

#### i. Client Eligibility date:

Enter date Client was determined eligible. Ensure both Client Eligibility and Energy Audit dates are within the Period of Eligibility. See **Section 1.3, *Period of Eligibility***

#### ii. Audit Date:

Enter date Energy Audit was performed.

#### iii. Client Interview Performed?

Answer yes/no

#### iv. Pollution Source Survey Completed?

Answer yes/no

#### v. Contaminants Present that would either prohibit blower door test completely, or require pressurization test:

(including but not limited to: Lead, Friable Asbestos, Mold, Smokers, Pets, Sewage, etc)

Document any contaminants or conditions that would prevent blower door testing or require pressurization testing.

#### vi. Technician:

Enter name of Technician performing: Pre, In-Progress, and Post diagnostic testing.

#### vii. Date:

Enter date Technician is performing: Pre, In-Progress, and Post diagnostic testing.

## Baseline Conditions & House Tightness – Blower Door

### Line #7 Primary heat source fuel type (example: nat gas, elec, propane, oil, wood)

Determine by interviewing (not their HIF or Wx application) the occupants, observing their habits and analyzing their heating bills what their primary heat source is and circle the type of fuel that is used in the appliance. Document the type (boiler, woodstove, forced air etc.) in the comments section.

### Line #8 Windspeed MPH

Record or estimate wind speed before setting up the blower door. Measure the wind speed with a wind gauge (record if there is apparent steady or gusting wind).

### Line #9 Outside temperature °F

Record outside temperature in degrees Fahrenheit

### Line #10 Blower door location

Record which doorway the blower door was mounted in for testing procedures. Mount the blower door in the doorway which has the least obstructions in the pathway of airflow (of the blower door) both inside and outside.

**Note:** Blower door set up procedure: follow manufacturer's instructions.

### Line #11 Baseline without blower door on in pa (stack effect)

Measure the house with reference to outside without the blower door running. Make sure the blower door fan is covered and the house is prepared for blower door testing.

### Line #12 Blower door configuration

**O=open fan A=ring A B=ring B LF=low flow ring**

Record which ring or configuration (number of holes unplugged) the blower door was set up in for testing lines 13 through 16.

**Note:** Always use the smallest ring possible to get the highest fan pressure when performing blower door testing. The higher the fan pressure the more accurate the test.

### Line #13 Total CFM50

Prepare the house for blower door testing. Normally test should be taken in the negative pressure mode, if positive pressure is used for testing note in the comments section and set up the house per manufacturer's specifications in the blower door manual.

## Zonal Pressures – Blower Door

### **Line# 14 Zonal Pressures**

Hook up your manometer as indicated on the field form for each test and record the pressure. Be sure to take verifying tests (house WRT zone, zone WRT outside, etc.). Start in a clockwise direction and describe room on the adjacent line and record pressures, zone WRT outside (confirming test: zone WRT outside).

### **Line #15 Location of existing ducts:**

**A=Inside B=outside C=inside/outside**

Determine and record where the duct system was designed to be located originally, inside the thermal boundary, outside the thermal boundary, or a combination of inside and outside.

### **Duct Pressure Test – Blower Door**

#### **Line #16 Duct Pressure Test – Pressure Pan**

**House WRT Duct (clockwise from front door)**

Face the front door looking out. Record (down to tenths) whether the duct tested is a supply or return duct and what zone it is located in from line #15. Record whether it is located inside or outside the intended thermal envelope (by design).

### **Testing Air Handler Effect – HVAC fan only**

The tests performed in lines 17 through 19 are performed with only the furnace air handler fan on. The blower door or any exhaust fans should be turned off during these tests. These tests indicate the effect of the air supply and return on pressures in rooms and the house.

#### **Line #17 Room Pressure:**

**Room WRT Main Body (interior doors closed)**

This testing is to see if there are large pressure differentials between rooms of the home that could possibly cause a problem to the operation of the combustion appliance or cause moisture damage the structure of the house.

#### **Line #18 Dominant Duct Leak Test:**

**Main Body WRT Outside (all interior doors open)**

Record the pressure of the main body of the house WRT outside with all interior doors open.

#### **Line #19 All Doors Closed Effect:**

**Main Body WRT outside (all interior doors closed)**

Now close all the interior doors and record main body WRT outside.

**Line #20 Duct location after Wx and repair:  
A=inside B=outside C=inside/outside**

Did you change the location of the ducts or are they in the same place as before? If as a result of the retrofit the location (inside to outside, outside to inside, etc.) of the duct system has been changed document in the comments section.

**Line #21 Electric furnace heat rise test:  
Heat Rise = supply°F – return°F**

With the electric furnace running, measure the temperature in the supply air plenum and return air plenum. Subtracting the return plenum temperature from the supply air temperature equals the “heat rise”. Take these temperature measurements in the plenums as close to the furnace as possible. Record in degrees Fahrenheit. The manufacturer’s acceptable range for heat rise for the unit is often on the nameplate of the furnace.

**\*\*Action level:** If the heat rise (the difference between return air temp at the plenum and supply air temp at the plenum) is outside the manufacturer’s acceptable range the system fails and there must be a referral made for further analysis by a furnace technician. If the heating unit has not been serviced within the last twelve months, a furnace clean and tune is recommended.

**Exception:** If manufacturer’s acceptable heat rise range is unavailable, the default acceptable heat rise range is greater than 40° and less than 70° Fahrenheit.

**Line #22 RETURN HOUSE Pre Test Conditions**

Check box when done.

**Exhaust Fan Testing**

**Line #23 Exhaust Fan Testing (Actual CFM)**

Test and record flow for all exhaust fans (local (source specific) and whole building (whole house)) using exhaust fan flow meter and digital pressure gauge.

Specifications:

Flow Accuracy: ±10% of reading when used with a 1% accurate pressure gauge with a display resolution of 0.1 Pa. (such as a DG-700)

Flow Range:

Door position E1 44 - 124 cfm

Door position E2 21 - 59 cfm

Door position E3 10 - 28 cfm

<b>FLOOR SUPPORT MATRIX</b>						
<b>Floor Type</b>	<b>Support Material</b>	<b>Material requirements</b>	<b>Maximum Spacing</b>	<b>Acceptable patterns</b>	<b>Minimum fastener type</b>	<b>Minimum fastener depth</b>
Joist up to 24"	Lath	3/8X1.5"	20"O.C.	Across floor joists	Corrosion resistant 3/8"crow 18AWG	5/8"
Joist up to 24"	Twine	150 LBS. polyester, polypropylene or nylon	12" O.C.	Shoelace/Zigzag (must be stapled at each joist)	Corrosion resistant 3/8"crow 18AWG	5/8"
Post &Beam over 32" O.C.	Lath	3/8X1.5"	20" O.C.	Across floor beams up to 54". If over 54" need center support	Corrosion resistant 3/8"crow 18AWG	5/8"
Post &Beam over 32" O.C	Twine	150 LBS. polyester, polypropylene or nylon	12"	Shoelace up to 54" across. If over 54" need center support	Corrosion resistant 3/8"crow 18AWG	5/8"

Appendix C

## Occupant Education>Forced Air systems Single-Family Homes

Title	Specification(s)	Objective(s)	
5.3003.7a Basic operation	Basic operation of the equipment will be explained to the occupant (e.g., design conditions, efficiency measures, differences from previous system or situation)	Ensure occupant has a reasonable expectation of the equipment's capability	2264
5.3003.7b System controls (e.g., thermostat, humidistat)	Proper operation and programming of system controls to achieve temperature and humidity control will be explained to the occupant	Ensure occupant can operate system controls	2265
5.3003.7c System disconnects	Indoor and outdoor electrical disconnects and fuel shut-offs will be demonstrated to occupant	Ensure occupant can shut off equipment in emergencies	2266
5.3003.7d Combustion air inlets	<p>Location of combustion air inlets will be identified for occupant in accordance with NFPA 31, 54, and 58</p> <p>Importance of not blocking inlets will be explained to occupant</p>	Ensure occupant does not block combustion air inlets	2267

Appendix C

## Occupant Education>Forced Air systems Single-Family Homes

	Title	Specification(s)	Objective(s)	
	5.3003.7e Blocking air flow	Importance of cleaning dust and debris from return grilles will be explained to occupant  Proper placement of interior furnishings with respect to registers will be explained to occupant  Negative consequences of closing registers will be explained to occupant  Importance of leaving interior doors open as much as possible will be explained to occupant	Ensure occupant does not prevent equipment from operating as designed	2268

Appendix C

## Occupant Education>Forced Air systems Single-Family Homes

	Title	Specification(s)	Objective(s)	
	5.3003.7f Routine maintenance	<p>Proper filter selection and how to change the filter will be explained to occupant</p> <p>Importance of keeping outside unit clear of debris, vegetation, decks, and other blockage will be explained to occupant</p> <p>Importance and timing of routine professional maintenance will be explained to occupant</p> <p>There will be no air bypass around the filters and new central forced air HVAC systems will have minimum MERV 6 filtration</p>	Ensure equipment operates as designed	2269

Appendix C

## Occupant Education>Forced Air systems Single-Family Homes

Title	Specification(s)	Objective(s)	
<p>5.3003.7g Calling heating, ventilation, and air conditioning (HVAC) contractor</p>	<p>Situations when the occupant should contact the HVAC contractor will be explained, including:</p> <ul style="list-style-type: none"> <li>• Fuel odors</li> <li>• Water draining from secondary drainline</li> <li>• Emergency heat indicator always on for a heat pump system</li> <li>• System blowing cold air during heating season and vice versa</li> <li>• Icing of the evaporator coil during cooling mode</li> <li>• Outside unit never defrosts</li> <li>• Unusual noises</li> <li>• Unusual odors</li> </ul>	<p>Notify occupant to contact installer when system is not operating as designed</p>	<p>2270</p>
<p>5.3003.7h Carbon monoxide (CO)</p>	<p>A carbon monoxide (CO) alarm will be installed</p>	<p>Occupant will be made aware of operation of CO alarm</p>	<p>2271</p>
<p>5.3003.7i Warranty and service</p>	<p>Occupant will be provided with relevant manuals and warranties</p> <p>The labor warranty will be explained and the occupant will be given a phone number to call for warranty service</p>	<p>Provide manuals and warranties for future servicing</p>	<p>2272</p>

**Checklist: ENCLOSED WALL CAVITY INSULATION (Dense Pack)**

**Project:**

✓	N/A	PREP	
<input type="checkbox"/>	<input type="checkbox"/>	<b>1</b>	Complete a combustion safety test and record the results.
<input type="checkbox"/>	<input type="checkbox"/>	<b>2</b>	Review ventilation strategy and plan any exhaust fan, electrical, or ducting install work before insulating.
<input type="checkbox"/>	<input type="checkbox"/>	<b>3</b>	Put on all personal protection equipment (PPE).
<input type="checkbox"/>	<input type="checkbox"/>	<b>4</b>	Identify all worker and occupant safety hazards.
<input type="checkbox"/>	<input type="checkbox"/>	<b>5</b>	Identify any exterior lead-based paint hazards and set up RRP-compliant containment accordingly.
<input type="checkbox"/>	<input type="checkbox"/>	<b>6</b>	Assess walls from the interior of home to identify weak plaster, drywall, or panelling.
<input type="checkbox"/>	<input type="checkbox"/>	<b>7</b>	Identify any durability issues such as signs of moisture or pests.
<input type="checkbox"/>	<input type="checkbox"/>	<b>8</b>	Address all combustion safety, worker safety, occupant safety and durability issues prior to starting work and notify the occupant. Do not complete work if a life safety hazard is identified.
✓	N/A	WORK	
<input type="checkbox"/>	<input type="checkbox"/>	<b>9</b>	Remove siding and drill through sheathing to gain access to all wall cavities and probe for obstructions and/or hazards.
<input type="checkbox"/>	<input type="checkbox"/>	<b>10</b>	Install insulation according to the manufacturer's specifications.
<input type="checkbox"/>	<input type="checkbox"/>	<b>11</b>	View completed sections using an IR camera with a blower door operating. Drill and repack any voids or low density areas.
<input type="checkbox"/>	<input type="checkbox"/>	<b>12</b>	Seal access points of all wall cavities and reinstall siding. Any new siding installed will match existing style and be primed and painted to match.
✓	N/A	CLOSE OUT	
<input type="checkbox"/>	<input type="checkbox"/>	<b>13</b>	Clean the work areas.
<input type="checkbox"/>	<input type="checkbox"/>	<b>14</b>	Educate the occupants on the work completed.
<input type="checkbox"/>	<input type="checkbox"/>	<b>15</b>	Post Insulation Certificate and insulation manufacturer's coverage chart.

**Checklist: FLOOR INSULATION**

**Project:**

✓	N/A	PREP
<input type="checkbox"/>	<input type="checkbox"/>	<b>1</b> Review ventilation strategy and plan any exhaust fan, electrical, or ducting install work before insulating.
<input type="checkbox"/>	<input type="checkbox"/>	<b>2</b> Put on all personal protection equipment (PPE).
<input type="checkbox"/>	<input type="checkbox"/>	<b>3</b> Identify all worker and occupant safety hazards.
<input type="checkbox"/>	<input type="checkbox"/>	<b>4</b> Identify any durability issues such as signs of moisture or pests.
<input type="checkbox"/>	<input type="checkbox"/>	<b>5</b> Address all combustion safety, worker safety, occupant safety and durability issues prior to starting work and notify the occupant. Do not complete work if a life safety hazard is identified.
✓	N/A	WORK
<input type="checkbox"/>	<input type="checkbox"/>	<b>6</b> Identify areas where insulation will not be installed.
<input type="checkbox"/>	<input type="checkbox"/>	<b>7</b> Remove existing damaged insulation from the crawlspace and/or basement.
<input type="checkbox"/>	<input type="checkbox"/>	<b>8</b> Complete air sealing according to location of pressure boundary (floor plane, perimeter, or combination): seal all holes between the crawlspace and/or basement and the interior and/or exterior of the house.
<input type="checkbox"/>	<input type="checkbox"/>	<b>9</b> Install insulation according to the manufacturer's specifications and Insulation Support Matrix. Verify that all insulation has no gaps, voids, compression or misalignment.
<input type="checkbox"/>	<input type="checkbox"/>	<b>10</b> Install baffles at foundation venting if needed.
✓	N/A	CLOSE OUT
<input type="checkbox"/>	<input type="checkbox"/>	<b>11</b> Clean the work areas.
<input type="checkbox"/>	<input type="checkbox"/>	<b>12</b> Educate the occupants on the work completed.
<input type="checkbox"/>	<input type="checkbox"/>	<b>13</b> Post Insulation Certificate and insulation manufacturer's coverage chart.

## Insulation Checklist - Attic

**Checklist: ATTIC INSULATION****Project:**

✓	N/A	PREP
<input type="checkbox"/>	<input type="checkbox"/>	<b>1</b> Review ventilation strategy and plan any exhaust fan, electrical, or ducting install work before insulating.
<input type="checkbox"/>	<input type="checkbox"/>	<b>2</b> Put on all personal protection equipment (PPE).
<input type="checkbox"/>	<input type="checkbox"/>	<b>3</b> Identify all worker and occupant safety hazards.
<input type="checkbox"/>	<input type="checkbox"/>	<b>4</b> Identify any durability issues such as signs of moisture or pests.
<input type="checkbox"/>	<input type="checkbox"/>	<b>5</b> Address all combustion safety, worker safety, occupant safety and durability issues prior to starting work and notify the occupant. Do not complete work if a life safety hazard is identified.
<input type="checkbox"/>	<input type="checkbox"/>	<b>6</b> If K&T present, confirm K&T inspection form complete.
<input type="checkbox"/>	<input type="checkbox"/>	<b>7</b> Confirm all working connections are in junction boxes.
✓	N/A	WORK
<input type="checkbox"/>	<input type="checkbox"/>	<b>8</b> Flag junction boxes.
<input type="checkbox"/>	<input type="checkbox"/>	<b>9</b> Install insulation depth measuring sticks.
<input type="checkbox"/>	<input type="checkbox"/>	<b>10</b> Identify areas where insulation will not be installed.
<input type="checkbox"/>	<input type="checkbox"/>	<b>11</b> Complete ceiling-plane air sealing: seal all holes between the interior of the house and the attic.
<input type="checkbox"/>	<input type="checkbox"/>	<b>12</b> Install baffles at low venting.
<input type="checkbox"/>	<input type="checkbox"/>	<b>13</b> Install insulation dams at attic accesses and around heat producing devices.
<input type="checkbox"/>	<input type="checkbox"/>	<b>14</b> Install insulation according to the manufacturer's specifications. Verify that all insulation has no gaps, voids, compression or misalignment.
✓	N/A	CLOSE OUT
<input type="checkbox"/>	<input type="checkbox"/>	<b>15</b> Clean the work areas.
<input type="checkbox"/>	<input type="checkbox"/>	<b>16</b> Educate the occupants on the work completed.
<input type="checkbox"/>	<input type="checkbox"/>	<b>17</b> Post Insulation Certificate and insulation manufacturer's coverage chart.

**Manufactured Home - Underfloor Insulation Precheck**

**Project:**

<input type="checkbox"/>	N/A	PREPARATION
<input type="checkbox"/>	<input type="checkbox"/>	<b>1</b> All plumbing supply leaks are repaired
<input type="checkbox"/>	<input type="checkbox"/>	<b>2</b> All plumbing drain leaks are repaired
<input type="checkbox"/>	<input type="checkbox"/>	<b>3</b> All forced air supply ducts are sealed, including trunk-lines and any jumper ducts
<input type="checkbox"/>	<input type="checkbox"/>	<b>4</b> Furnace plenum connection to trunk-line duct is sealed
<input type="checkbox"/>	<input type="checkbox"/>	<b>5</b> Cross over duct is installed or repaired to specification (see Fied Guide 3.1602.9b - Crossover ducts)
<input type="checkbox"/>	<input type="checkbox"/>	<b>6</b> All floor-plain air sealing is complete, including marriage line, hole under the tub, plumbing penetrations, and electrical penetrations
<input type="checkbox"/>	<input type="checkbox"/>	<b>7</b> All combustion air inlets that are ducted into crawlspace are maintained (they could be for wood stove, pellet stove, water heater, furnace)
<input type="checkbox"/>	<input type="checkbox"/>	<b>8</b> All belly repairs and patching are complete
<input type="checkbox"/>	<input type="checkbox"/>	<b>9</b> Belly material is pinned up against floor joists where possible in odrer to reduce sag and amount of insulation needed

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Appendix D

**Manufactured Home - Attic Insulation Precheck**

**Project:**

<input type="checkbox"/>	N/A	PREPARATION
<input type="checkbox"/>	<input type="checkbox"/>	<b>1</b> All combustion appliance venting and flues maintain clearance to combustibles, unless zero clearance flue is in place
<input type="checkbox"/>	<input type="checkbox"/>	<b>2</b> All ventilation systems maintain a continuous connection and terminate to the outdoors
<input type="checkbox"/>	<input type="checkbox"/>	<b>3</b> All plumbing stacks are terminated to the outdoors
<input type="checkbox"/>	<input type="checkbox"/>	<b>4</b> Non-IC rated light fixtures are replaced with air-tight IC rated fixtures
<input type="checkbox"/>	<input type="checkbox"/>	<b>5</b> All ceiling-plane air sealing is complete, including marriage line, passive jumper ducts, and skylights
<input type="checkbox"/>	<input type="checkbox"/>	<b>6</b> All roof, attic, and ceiling assemblies are structurally sound
<input type="checkbox"/>	<input type="checkbox"/>	<b>7</b> Dishing and pooling issues of the roof that allow standing water are addressed
<input type="checkbox"/>	<input type="checkbox"/>	<b>8</b> All known roof leaks are repaired

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**WALLS - common air leakage details include but are not limited to:**

**Project:**

✓	N/A	PREPARATION
<input type="checkbox"/>	<input type="checkbox"/>	<b>1</b> Openings behind and under tubs, showers, and tub/shower enclosures
<input type="checkbox"/>	<input type="checkbox"/>	<b>2</b> Annular space at wiring, pipe penetrations through plates, and at ceiling fixtures
<input type="checkbox"/>	<input type="checkbox"/>	<b>3</b> Pocket door framing open into floor or attic above and exterior walls
<input type="checkbox"/>	<input type="checkbox"/>	<b>4</b> Seams and openings in walls and ceilings between attached garages and house
<input type="checkbox"/>	<input type="checkbox"/>	<b>5</b> All joints seams and penetrations in surfaces without an air retarding membrane
<input type="checkbox"/>	<input type="checkbox"/>	<b>6</b> Gaps in tongue in groove paneling where angles change at hips, valleys, and where walls meet slants and ceilings
<input type="checkbox"/>	<input type="checkbox"/>	<b>7</b> Built-in cabinets, dressers or book shelves in knee walls.
<input type="checkbox"/>	<input type="checkbox"/>	<b>8</b> Common wall openings between dwelling units
<input type="checkbox"/>	<input type="checkbox"/>	<b>9</b> Rim joist junctions and gaps between sill and foundation, including open block cores
<input type="checkbox"/>	<input type="checkbox"/>	<b>10</b> Utility penetrations and direct openings through foundation walls
<input type="checkbox"/>	<input type="checkbox"/>	<b>11</b> Openings in gypsum board including un-taped joints above suspended ceiling and behind cabinets
<input type="checkbox"/>	<input type="checkbox"/>	<b>12</b> Openings between window and door assemblies and their respective jambs and framing when no interior or exterior trim is present

**FLOOR PLANE - common air leakage details include but are not limited to:**

**Project:**

✓	N/A	PREPARATION
<input type="checkbox"/>	<input type="checkbox"/>	<b>1</b> Plumbing wet walls, duct chases, duct seams, joints and boot leaks
<input type="checkbox"/>	<input type="checkbox"/>	<b>2</b> Openings behind and under tubs, showers, and tub/shower enclosures
<input type="checkbox"/>	<input type="checkbox"/>	<b>3</b> Annular space at wiring, pipe penetrations through plates, and at ceiling fixtures
<input type="checkbox"/>	<input type="checkbox"/>	<b>4</b> Floors open under knee walls, walls open at level changes and gable ends
<input type="checkbox"/>	<input type="checkbox"/>	<b>5</b> Pocket door framing open into floor or attic above and exterior walls
<input type="checkbox"/>	<input type="checkbox"/>	<b>6</b> All joints seams and penetrations in surfaces without an air retarding membrane
<input type="checkbox"/>	<input type="checkbox"/>	<b>7</b> Gaps below baseboard and behind carpet nailing strip at subfloor joint to exterior wall
<input type="checkbox"/>	<input type="checkbox"/>	<b>8</b> Rim joist junctions and gaps between sill and foundation, including open block cores

**ATTIC - common air leakage details include but are not limited to:**

**Project:**

✓	N/A	PREPARATION
<input type="checkbox"/>	<input type="checkbox"/>	<b>1</b> Dropped soffits, dropped ceilings and ceiling height changes
<input type="checkbox"/>	<input type="checkbox"/>	<b>2</b> Plumbing wet walls, duct chases, duct seams, joints and boot leaks
<input type="checkbox"/>	<input type="checkbox"/>	<b>3</b> Chimney and combustion vent chases
<input type="checkbox"/>	<input type="checkbox"/>	<b>4</b> Wall tops open into attic, gaps between gypsum ceiling and wall plates
<input type="checkbox"/>	<input type="checkbox"/>	<b>5</b> Annular space at wiring, pipe penetrations through plates, and at ceiling fixtures
<input type="checkbox"/>	<input type="checkbox"/>	<b>6</b> 2 <sup>nd</sup> story floors open to attached roofs over porches and additions or garages
<input type="checkbox"/>	<input type="checkbox"/>	<b>7</b> Inside framing open into attic stairs and landings
<input type="checkbox"/>	<input type="checkbox"/>	<b>8</b> Pocket door framing open into floor or attic above and exterior walls
<input type="checkbox"/>	<input type="checkbox"/>	<b>9</b> Non-IC recessed light fixtures. IC rated fixtures with no airtight insert
<input type="checkbox"/>	<input type="checkbox"/>	<b>10</b> Bath and kitchen fans venting into the attic
<input type="checkbox"/>	<input type="checkbox"/>	<b>11</b> All joints seams and penetrations in surfaces without an air retarding membrane
<input type="checkbox"/>	<input type="checkbox"/>	<b>12</b> Gaps in tongue in groove paneling where angles change at hips, valleys, and where walls meet slants and ceilings
<input type="checkbox"/>	<input type="checkbox"/>	<b>13</b> Acoustical tile and suspended ceilings with no solid ceiling above.
<input type="checkbox"/>	<input type="checkbox"/>	<b>14</b> Missing gypsum behind decorative ceiling light trays or above decorative ceiling beams
<input type="checkbox"/>	<input type="checkbox"/>	<b>15</b> Built-in cabinets, dressers or book shelves in knee walls.
<input type="checkbox"/>	<input type="checkbox"/>	<b>16</b> Attic access openings, operable doors and hatches without tight weather-strip
<input type="checkbox"/>	<input type="checkbox"/>	<b>17</b> Pull down attic access stair or cover
<input type="checkbox"/>	<input type="checkbox"/>	<b>18</b> Attic floor where interior surface will not support dense pack, has weak plaster, active Knob and Tube (K&T), non IC lights, vermiculite, etc.

**AIR SEALING - common air leakage details include but are not limited to:**

**Project:**

✓	N/A	PREPARATION
<input type="checkbox"/>	<input type="checkbox"/>	<b>1</b> Dropped soffits, dropped ceilings and ceiling height changes
<input type="checkbox"/>	<input type="checkbox"/>	<b>2</b> Plumbing wet walls, duct chases, duct seams, joints and boot leaks
<input type="checkbox"/>	<input type="checkbox"/>	<b>3</b> Chimney and combustion vent chases
<input type="checkbox"/>	<input type="checkbox"/>	<b>4</b> Openings behind and under tubs, showers, and tub/shower enclosures
<input type="checkbox"/>	<input type="checkbox"/>	<b>5</b> Wall tops open into attic, gaps between gypsum ceiling and wall plates
<input type="checkbox"/>	<input type="checkbox"/>	<b>6</b> Annular space at wiring, pipe penetrations through plates, and at ceiling fixtures
<input type="checkbox"/>	<input type="checkbox"/>	<b>7</b> Floors open under knee walls, walls open at level changes and gable ends
<input type="checkbox"/>	<input type="checkbox"/>	<b>8</b> 2 <sup>nd</sup> story floors open to attached roofs over porches and additions or garages
<input type="checkbox"/>	<input type="checkbox"/>	<b>9</b> Inside framing open into attic stairs and landings
<input type="checkbox"/>	<input type="checkbox"/>	<b>10</b> Pocket door framing open into floor or attic above and exterior walls
<input type="checkbox"/>	<input type="checkbox"/>	<b>11</b> Seams and openings in walls and ceilings between attached garages and house
<input type="checkbox"/>	<input type="checkbox"/>	<b>12</b> Non-IC recessed light fixtures. IC rated fixtures with no airtight insert
<input type="checkbox"/>	<input type="checkbox"/>	<b>13</b> Bath and kitchen fans venting into the attic
<input type="checkbox"/>	<input type="checkbox"/>	<b>14</b> All joints seams and penetrations in surfaces without an air retarding membrane
<input type="checkbox"/>	<input type="checkbox"/>	<b>15</b> Gaps in tongue in groove paneling where angles change at hips, valleys, and where walls meet slants and ceilings
<input type="checkbox"/>	<input type="checkbox"/>	<b>16</b> Acoustical tile and suspended ceilings with no solid ceiling above.
<input type="checkbox"/>	<input type="checkbox"/>	<b>17</b> Missing gypsum behind decorative ceiling light trays or above decorative ceiling beams
<input type="checkbox"/>	<input type="checkbox"/>	<b>18</b> Built-in cabinets, dressers or book shelves in knee walls.
<input type="checkbox"/>	<input type="checkbox"/>	<b>19</b> Gaps below baseboard and behind carpet nailing strip at subfloor joint to exterior wall
<input type="checkbox"/>	<input type="checkbox"/>	<b>20</b> Common wall openings between dwelling units
<input type="checkbox"/>	<input type="checkbox"/>	<b>21</b> Attic access openings, operable doors and hatches without tight weather-strip
<input type="checkbox"/>	<input type="checkbox"/>	<b>22</b> Pull down attic access stair or cover
<input type="checkbox"/>	<input type="checkbox"/>	<b>23</b> Rim joist junctions and gaps between sill and foundation, including open block cores
<input type="checkbox"/>	<input type="checkbox"/>	<b>24</b> Utility penetrations and direct openings through foundation walls
<input type="checkbox"/>	<input type="checkbox"/>	<b>25</b> Openings in gypsum board including un-taped joints above suspended ceiling and behind cabinets
<input type="checkbox"/>	<input type="checkbox"/>	<b>26</b> Openings between window and door assemblies and their respective jambs and framing when no interior or exterior trim is present
<input type="checkbox"/>	<input type="checkbox"/>	<b>27</b> Attic floor where interior surface will not support dense pack, has weak plaster, active Knob and Tube (K&T), non IC lights, vermiculite, etc.



## State of Washington, Weatherization Assistance Program

### Technical Support Document

# Mechanical Ventilation Worksheet

ASHRAE 62.2-2016

This document is intended to support in detail the Mechanical Ventilation Worksheet (Exhibit 9.3). The worksheet is designed to be both a calculation and documentation tool. **The Mechanical Ventilation Worksheet is only for calculating projects using a continuous whole building ventilation strategy and for which all necessary inputs are reflected on the sheet.** For all other projects within the scope of ASHRAE 62.2-2016, refer to the Intermittent Calculation sheet of this tool, or refer directly to the standard for calculation guidance.

The upper portion of the Mechanical Ventilation Worksheet is for recording pre-weatherization conditions of the project and to help estimate continuous ventilation to be added.

The lower portion of the Mechanical Ventilation Worksheet is for recording post-weatherization conditions and documenting compliance with ASHRAE 62.2-2016.

User entries to the worksheet are made in the GREEN BOXES.

NOTE: For best results ALWAYS use a fresh worksheet template. For user convenience some of the data transfers to other areas of the sheet. Starting with a fresh template will help ensure old data is not causing an erroneous result.

For convenient simplified instructions while working on the worksheet simply hover the cursor over cells with a red triangle in the upper right hand corner. Comment boxes should appear with abbreviated help notes.

### **Line #1 Pre-Weatherization Blower Door Reading (CFM50)**

Enter the CFM50 from the initial audit prior to any weatherization work per Commerce s4.1.

**Line #2 People**

Enter the total number of occupants. May not be less than one. *Per ASHRAE 62.2-2016 section 4.1.1*

**Line #3 Bedrooms**

Enter the number of bedrooms. Not to be less than one. *Per ASHRAE 62.2-2016 section 4.1*

*Calculation:* The yellow box on this line calculates (number of bedrooms +1)\*7.5 OR (number of occupants)\*7.5, whichever is greater. *Per ASHRAE 62.2-2016 section 4.1.1*

**Line #4 Conditioned Square Footage**

Enter total conditioned square footage for the building.

*Calculation:* The yellow box on this line calculates (conditioned square footage)\*.03 *Per ASHRAE 62.2-2016 section 4.1.1*

**Line #5 Total Ventilation Required ( $Q_{tot}$ )**

This is a calculated value as defined as  $Q_{tot}$  in ASHRAE 62.2-2016 section 4.1. This value will be at, or below the value shown in ASHRAE 62.2-2016 table 4.1a.

**Note regarding lines #6-9**

**This section is to determine any local exhaust deficits. Each line has four possible boxes for user entry. The first two boxes on the left of each line require a “y” entry if the room exists in the building or an operable window exists in a room. You may enter “n” in these boxes if the response is no, or leave the box blank. The entire line may be left blank if the “room exists” response is no.**

The default inputs are “y” for Kitchen and Bath 1 (as it is assumed that each dwelling unit being considered will have one of each), though this input is easily changed if necessary.

The default deficit on each line is “None”. When the room indicator is set to “y” the required intermittent ventilation will show in the deficit column. ASHRAE 62.2-2016 does not require these deficits to be overcome but the whole building ventilation system must make up for any deficiency. Consult Commerce specifications, especially section 10, for other fan location requirements dependent upon building conditions such as excess moisture and gas ranges.

STRATEGY NOTE: Experimenting with different fan strategies on lines 6-10 can help the auditor achieve a whole building ventilation strategy using lower-CFM continuous fans in required ventilation rooms. For file documentation purposes return the entries in the boxes to the actual measured values prior to printing, or saving the document.

**This section assumes all fans entered are properly vented, or will be vented to the exterior during the weatherization process.**

## Line #6 Kitchen

In the “Intermittent Measured Fan” column enter the measured fan flow in cubic feet per minute (CFM) for any existing intermittent fan which is vented to the exterior of the building. See Commerce specification 10.0.3 for additional information flow measurement and exceptions. This column may be left blank if there is no fan, the fan has no flow, or is not vented to the exterior.

IF a continuous fan exists calculate the air changes per hour (ach) and enter this value in the “Continuous Measured” column. To calculate air changes per hour determine measured fan flow rate per hour (fan CFM\*60) and divide it by the volume of the kitchen (Volume = length\*width\*height).

- Example: Kitchen dimensions are: 10’ width by 12’ length by 8’ height and the continuous measured fan flow is 22 CFM. Volume =  $10*12*8 = 960$  cubic feet, Hourly fan flow =  $22*60 = 1320$  cubic feet per hour,  $1320/960 = 1.375$  ach.

If kitchen ventilation is provided by a range hood, it is required to have a flow of at least 100 CFM. Any other mechanical ventilation in the kitchen (such as a downdraft fan) must have a flow of 300 CFM.

According to the ASHRAE 62.2-2016 standard, there are two types of kitchens: enclosed and nonenclosed. An *enclosed* kitchen is defined as one that has permanent openings to interior adjacent spaces that do not exceed a total of 60 square feet. An *enclosed* kitchen is required to have mechanical ventilation that provides at least 5 air changes per hour (ACH), whether through the use of a range hood or other mechanical ventilation.

A *nonenclosed* kitchen has permanent openings to interior adjacent spaces in excess of a total of 60 square feet. A *nonenclosed* kitchen is more highly connected to the main body of the home, so there is no ACH criterion to fulfill. A *nonenclosed* kitchen is required, as is an enclosed kitchen, to have mechanical ventilation which provides 100 CFM (if delivered by a range hood) or 300 CFM (if delivered by a other mechanical ventilation, such as a range hood).

## Line #7 through #9 Bath 1, 2 or 3

Enter only rooms meeting the definition of a bathroom on these lines. ASHRAE 62.2-2016 defines a bathroom as “any room containing a bathtub, a shower, a spa, or a similar source of moisture.” Do NOT enter ½ baths, water closets etc\*.

Enter existing intermittent fan flows in the third column of this section. If continuous fans exist enter the fan flow in CFM in the fourth column.

*\*Note: Intermittent fans in ½ baths, water closets, laundry rooms etc. shall not be entered on this worksheet. Properly vented continuous fans in these types of areas should be listed on lines 18 and 36.*

**Line #10 Total Deficit**

This line represents the existing deficit in local ventilation per ASHRAE 62.2-2016 Normative Appendix A *especially section A3.1*.

**Line #11 Required Additional Airflow**

The additional airflow required is the total deficit divided by four (per ASHRAE 62.2-2016 Normative Appendix A *especially section A3.3*). This ventilation requirement can be overcome by addressing local ventilation issues in rooms requiring specific ventilation, through the whole building ventilation fan, or a combination of both.

**Line #12 Needed Ventilation Estimate (prior to credits)**

This entry is a sum of lines 5 and 11.

**Line #13 Actual Infiltration Estimate (Q<sub>inf</sub>)**

For most accurate estimate enter a blower door reading taken after air sealing and any other measures significantly affecting building tightness in the first box. If no other reading is entered, CFM50 from line 1 will automatically transfer here.

Dwelling unit height is defined in ASHRAE 62.2-2016 as the “vertical distance between the lowest and highest above-grade points within the pressure boundary” (in feet).

Select a city from the drop-down menu on the left side of the worksheet which most accurately reflects the location and climatic conditions for the building being considered. This selection determines the WSF (weather and shielding factor, from Normative Appendix B) used to complete the calculation of Q<sub>inf</sub>. *Note: Portland Oregon is included to more accurately address conditions in southwest Washington.*

The third box on this line is the calculation of Q<sub>inf</sub>. According to ASHRAE 62.2-2016, Addendum i:

$$Q_{inf} = CFM@50 * 0.052 * WSF * [(dwelling\ unit\ height/reference\ height)^{.4}]$$

where dwelling unit height is as defined above, and the reference height is 8.2 feet.

**Line #14 Assumed Infiltration (hidden columns)**

ASHRAE 62.2-2016 assumes an infiltration rate of 2CFM per square foot of the building. The first box on this line reflects the square footage entered on line 4. The second box is a function of the square footage multiplied by .02.

**Line #15 Infiltration actual minus assumed (hidden columns)**

This line is merely a function of the actual measured infiltration from line 13 less the ASHRAE assumed value on line 14. If the value is zero or less there will be no infiltration credit and the assumed value is automatically included in the required ventilation calculation.

**Line #15 Calculating  $A_{ext}$  for attached dwelling units**

This line is also the beginning of the section used to calculate  $A_{ext}$  (a term used for horizontally attached dwelling units only). The complete calculation for  $Q_{fan}$  is given in ASHRAE 62.2-2016 equation 4.6 as

$$Q_{fan} = Q_{tot} - (Q_{inf} \times A_{ext})$$

where

$$A_{ext} = \frac{\text{(Exterior envelope surface area that is not attached to garages or other dwelling units)}}{\text{(Total envelope surface area)}}$$

and modifies the infiltration credit proportionately. (Note that  $A_{ext}$  should be calculated even for dwelling units attached only via garage demising walls.)  $A_{ext}$  is always equal to 1 for detached dwelling units, making this calculation only necessary for attached dwelling units.

If the dwelling unit under consideration is vertically attached (shares any part of its floor or ceiling with another dwelling unit), check the box in this section. No infiltration credit is given for stacked dwelling units ( $Q_{inf} = 0$ ).

**Line #16 Infiltration Credit (hidden columns)**

The infiltration credit allowed is  $\frac{1}{2}$  of the difference between the actual and assumed ventilation. No increase is required if the measured infiltration is lower than the assumed rate.

**Line #17 Sum of existing bathroom ventilation**

ASHRAE 62.2 currently does not include a provision for partial credit of continuous local ventilation in the deficit calculation (lines 6-10). Continuous ventilation is included in lines 6-10 for the purpose of overcoming the deficit, if the fan flow is in excess of the required amounts (5 ACH, 100 or 300 CFM for kitchens, and 20 CFM for bathrooms). These continuous amounts should be counted as part of a whole building continuous strategy. Any continuous bath fan ventilation is summed and transferred to this line. (See also Strategy Note below, regarding lines #6-9 above)

**Line #18 Other Continuous Ventilation (including kitchen CFM)**

If there is any other existing continuous ventilation that is expected to remain (such as in laundry rooms,  $\frac{1}{2}$  baths, water closets, whole building, etc.) sum all CFM and enter it here. If continuous kitchen ventilation was entered in ach on line 6 the actual CFM must be manually entered as part of this line total.

**Line #19 Estimated Continuous Ventilation to Add**

This line is the estimated continuous ventilation needed to meet ASHRAE 62.2-2016. The value is a function of line 12 subtracting lines 16, 17 and 18. If the total is less than zero the box will indicate “None”.

*STRATEGY NOTE: Experimenting with different fan strategies on lines 6-10 can help the auditor achieve a whole building ventilation strategy using lower CFM continuous fans in required ventilation rooms. For file documentation purposes, return the entries in the boxes to the actual measured values prior to printing or saving the document.*

### **Estimate Notes**

Be sure to record any relevant pre-weatherization or estimate notes in the box for file documentation.

### **Lines #20-23**

All instructions for these lines are synonymous to the corresponding cells in lines #2-5 above. For user convenience, values will transfer from original entries. If people, bedrooms, or square footage have changed, simply enter the new values in the green boxes.

### **Lines #24-27**

All instructions for these lines are synonymous to the corresponding cells in lines #6-9 above. For user convenience, values will transfer from original entries in the “room exists” and “operable window” columns. Post weatherization (final flow) measurements are required for all required fans. These numbers must be manually entered in this section when utilizing the Mechanical Ventilation Worksheet to demonstrate compliance with the standard.

### **Lines #28-30**

No entry required. All instructions and explanations for these lines are synonymous to the corresponding cells in lines #10-12 above.

### **Line #31 Final Blower Door CFM50 and Actual Infiltration ( $Q_{inf}$ )**

Enter the post weatherization blower door number in CFM50 and the dwelling unit height. The actual building infiltration will be calculated automatically using the new CFM50 according to the same calculations as in line #13 (see above).

### **Lines #32-34**

No entry required. All instructions and explanations for these lines are the same as lines #14-16 above.

### **Line #35 Sum of Continuous Bath Fan Ventilation**

No entry required. All instructions and explanations for this line are the same as line #17 above.

### **Line #36 Other Continuous Ventilation (including kitchen CFM)**

Enter the total CFM of all continuous ventilation that **is not** shown on lines 25-27.

**IMPORTANT NOTE Any continuous kitchen ventilation entered in ach on line 24 must be manually entered in CFM as part of this line total** (Measure post weatherization CFM of continuous kitchen fan or use other approved Commerce/ASHRAE 62.2-2016 method to determine flow value).

### **Line #37 Continuous Ventilation Required**

This line is the continuous ventilation still needed to meet ASHRAE 62.2-2016. The value is a function of line 61 subtracting lines 34, 35 and 36. This value must be at, or less than “0” to demonstrate compliance to the standard. A negative number represents the amount of over-ventilation installed. Adjust fans/ventilation strategy to get the closest result to “0” if the equipment and building conditions allow it.

### **Final Project Notes**

Be sure to record any relevant post-weatherization or other final notes in the box for file documentation.

### **Abbreviations:**

**ach:** air changes per hour

**CFM:** cubic feet per minute

**CFM50:** leakage rate measured at a pressure of 50 pascals

**Terms:**

**Air handler** – A steel cabinet containing a blower with cooling and/or heating coils connected to ducts, which transport indoor air to and from the air handler.

**Backdrafting** – Continuous spillage of combustion gases from a combustion appliance.

**Bimetal element** – A metal spring, lever, or disc made of two dissimilar metals that expand and contract at different rates as the temperature around them changes. This movement operates a switch in the control circuit of a heating or cooling device.

**Burner** – A device that facilitates the burning of a fossil fuel like gas or oil.

**Carbon monoxide** – An odorless and poisonous gas produced by incomplete combustion.

**Combustion air** – Air that chemically combines with a fuel during combustion to produce heat and flue gases, mainly carbon dioxide and water vapor.

**Combustion analyzer** – A device used to measure steady-state efficiency of combustion heating units.

**Depressurize** – Cause to have a lower pressure or vacuum with respect to a reference of a higher pressure.

**Dilution air** – Air that enters through the dilution device --- an opening where the chimney joins to an atmospheric-draft combustion appliance.

**Dilution device** – A draft diverter or barometric draft control on an atmospheric-draft combustion appliance.

**Draft diverter** – A device located in gas appliance chimneys that moderates draft and diverts down drafts that could extinguish the pilot or interfere with combustion.

**Fan control** – A bimetal thermostat that turns the furnace blower on and off as it senses the presence of heat.

**Flue** – a channel for combustion gases.

**Heat anticipator** – A very small electric heater in a thermostat that causes the thermostat to turn off before room temperature reaches the thermostat setting, so that the house does not overheat from heat remaining in the furnace and ducts after the burner shuts off.

**Heat rise** – The number of degrees of temperature increase that air is heated as it is blown over the heat exchanger. Heat rise equals supply temperature minus return temperature.

**High limit** – A bimetal thermostat that turns the heating element of a furnace off if it senses a dangerously high temperature.

**House pressure** – The difference in pressure between the indoors and outdoors measured by a manometer.

**Inch of water** – Small air pressure differences caused by wind, blower doors, furnace fans, and chimneys are measured in inches of water (in.-H<sub>2</sub>O) in the American measurement system.

**Input rating** – The rate at which an energy-using device consumes electricity or fossil fuel.

**Intermittent ignition device** – A device that lights the pilot light on a gas appliance when the control system calls for heat thus saving the energy wasted by a standing pilot.

**Make-up air** – Air supplied to a space to replace exhausted air.

**Manometer** – Measuring device for small gas pressures

**Mortar** – A mixture of sand, water, and cement used to bond bricks, stones, or blocks together.

**Net free area** – The area of a vent after that area has been adjusted for insect screen, louvers, and weather coverings. The free area is always less than the actual area.

**Open-combustion heater** – A heating device that takes its combustion air from the surrounding room air.

**Orphaned Natural Draft Water Heater** - A natural draft water heater vented into an oversized chimney.

**Oxygen depletion sensor (ODS)** – A safety device for unvented combustion heaters that shuts gas off when oxygen is depleted.

**Pascal** – A unit of measurement of air pressure. (See Inch of water.)

**Plenum** – The piece of ductwork that connects the air handler to the main supply duct.

**Pressure** – A force encouraging movement by virtue of a difference in some condition between two areas.

**Return air** – Air circulating back to the furnace from the house, to be heated by the furnace and supplied to the rooms.

**Room heater** – A heater located within a room and used to heat that room.

**Sealed-combustion heater** – A heater that draws combustion air from outdoors and has a sealed exhaust system.

**Space heating** – Heating the living spaces of the home with a room heater or central heating system.

**Spillage** – Temporary flow of combustion gases from a dilution device.

**Stack effect** – The draft established in a building from air infiltrating low and exfiltrating high.

**Stand-Alone Natural Draft Water Heater** - A natural draft water heater vented into a properly-sized chimney in accordance with NFPA 31 for oil-fired units, NFPA 54 for gas-fired units, NFPA 58 for propane-fired units and NFPA 211 for solid-fueled units or the venting tables of a chimney liner manufacturer.

**Steady-state efficiency** – The efficiency of a heating appliance, after an initial start-up period, that measures how much heat crosses the heat exchanger. A combustion analyzer measures the steady-state efficiency.

**Supply air** – Air that has been heated or cooled and is then moved through the ducts and out the supply registers of a home.

**Vent connector** – The vent pipe carrying combustion gases from the appliance to the chimney.

**Vent damper** – An automatic damper powered by heat or electricity that closes the chimney while a heating device is off.

**Venting** – The removal of combustion gases by a chimney.

**Worst-case depressurization test** – A safety test, performed by specific procedures, designed to assess the probability of chimney back drafting.

**WRT** – “With respect to” used to show that the air pressures between two areas are being compared.

**Zone** – A room or portion of a building separated from other rooms by an air barrier----not usually an effective air barrier.

## Appendix G

# Multifamily Homes

The NREL MF SWS applies to all buildings containing more than 5 units. View the MF SWS online at <https://sws.nrel.gov> for more information