

# Oregon Weatherization Assistance Program Site Built and Manufactured Home Field Guide and Standards





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## Acknowledgements:

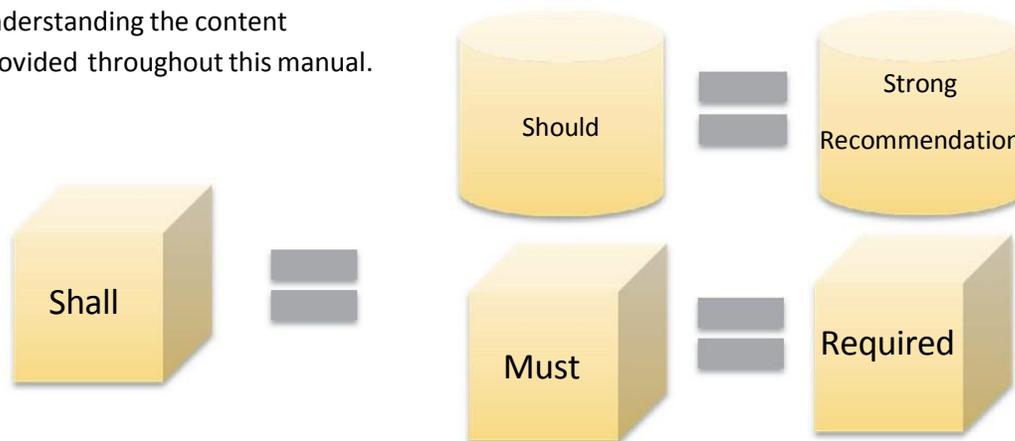
The Oregon Energy Coordinators Association in collaboration with the Community Action Agencies throughout Oregon, Oregon Housing and Community Services, The Energy Conservatory, Minneapolis, MN; Pacific Power, Portland General Electric, Rees Byars, South Carolina Weatherization Program; Drawings by Kurt Torgerson, Clackamas County Weatherization; photos from weatherization programs in and around the State of Oregon and special recognition for the hours of review, by Steve Divan, Judy Swendsen, Randy Olsen, Jacque Meier, Ken Centner, Tyson Payne, Kale Elmer, Linda Roberts, April Richey, Joe Vollmar, Dan Hughes, Rogelio Cortez, Jaycob Padron, Jose Flores, Jim Minix, Eric Shaw, Kurt Pugh and Tim Zimmer.

**Oregon Building Codes apply to all homes.** Building codes include specifications on components and allowable installation methodologies.

## How to use this manual

### Key Terminology

The intended meaning of the frequently- used-terminology illustrated here is key to understanding the content provided throughout this manual.



### Standard Work Specifications

The Standard Work Specifications (SWS) are a major component of the Guidelines for Home Energy Professionals project and define the minimum requirements to ensure that the work performed during home energy upgrades is effective, durable, and safe. Where applicable, you will see the relevant SWS(s) referenced. To view the SWS cited, you may go to the [NREL SWS website \(www.sws.nrel.gov\)](http://www.sws.nrel.gov) to view the specifics of the SWS. Example:

- 1.03 Insulation will be adequately marked for depth a minimum of every 300 square feet of attic area, with measurement beginning at the air barrier (SWS 4.1005.1a-2a)



## **Section 0 : General Installer Requirements**

### **00.01 Health & Safety**

1. All worker safety specifications in the Global Worker Safety section must be followed. (SWS 2.0100.1, , 2.0102.1a, 2.0103.1a) See Appendix AA for details.
2. Asbestos protocols must be followed if necessary. (SWS 2.0102.1B)
3. All materials must be handled in accordance with manufacturer specifications or Safety Data Sheets (SDS) (SWS 2.0102.1c)
4. Presence of lead based paint in pre-1978 homes will be assumed unless testing confirms otherwise. All lead paint protocols must be followed when required. (SWS 2.102.1a-d)

**00.02** Weatherization measures shall be installed in accordance to the specifications cited in this document, all applicable Oregon state codes and federal regulations, which may include the most recent versions of the Uniform Building Code (UBC) and the National Electric Code (NEC) and Uniform Mechanical Code (UMC).

**00.03** Where state and local codes or specification regulations are in conflict, the most stringent requirement shall apply. When state and local codes are less restrictive, Oregon Housing & Community Services (OHCS) may approve their use in lieu of these specifications. Such approval shall be requested and approved in writing by OHCS before the measure is installed.

**00.04** If a specific application is not addressed in the specifications, codes or regulations; the agency shall consult OHCS to determine appropriate action consistent with the codes, regulations and these specifications.

**00.05** Upon completion of weatherization work, a signed and dated insulation certificate indicating square footage insulated, R-value installed, type of insulation and bag count shall be posted at the job site. The number of bags installed must be confirmed and must match the number required on the coverage chart. In addition, the coverage chart off of the Insulation bag must be posted on the jobsite. A copy of the insulation certificate must be included in the job file.

**00.06** All materials installed shall meet Federal Material Specification and Standards listed in Appendix X. Installers are responsible for knowing whether their products comply with this specification and are therefore eligible for installation under the program.

- 00.07** The installer shall warrant weatherization materials and labor against failure due to manufacturing and installation defects for a period of a least one year. It shall be the installer's responsibility to file a claim for replacement of any installed warranted material that carries a manufacturer's warranty in excess of one year. (SWS 2.0702.1a-b)
- 00.08** When the installer evidences structural damage by obvious water stains, dry rot, termites, etc. it shall be immediately called to agency's attention.
- 00.09** The installer shall indicate to the client in writing any materials or components being replaced which are assumed to become the property of the installer (i.e., salvage).
- 00.10** Installers shall procure all permits, materials, and labor necessary to install weatherization measures in the residence unless noted elsewhere in this specification book.
- 00.11** Each job site shall be left clean (free of debris and surplus) at the completion of each job. Any damage resulting from the installation of measures shall be repaired at installer's expense.
- 00.12** Access to the most recent revision of these specifications shall be provided to each contractor by the agency for which they are providing services. Access may include either a link to the document, digital copy or a printed copy. A confirmation of receipt for this document shall be kept in each installer's file. Confirmation of receipt may be included in the agency/contractor contract. Contractors must ensure all crewmembers are provided with access to a copy of the field guide and trained in the content.
- 00.13** The installer shall obtain from the Oregon Construction Contractors Board (CCB) a Lead-Based Paint Renovation (LBPR) contractor's license, when working on homes that may contain lead based paint or were built before 1978. See the Oregon CCB's website for more information. If the installer is exempt from the requirements to have a CCB license then the installer's business must file with the Oregon Health Authority as a lead certified firm.

## Section 1 : Ceiling Insulation

- 1.01 General:** Material shall be installed according to the provisions of the current Oregon Building Code or other applicable codes and shall meet the requirements of agency weatherization program. Any exceptions shall be approved in writing in advance by the agency.

Upon completion of weatherization work, a signed and dated insulation certificate indicating square footage insulated, R-value installed, type of insulation and bag count shall be posted at the job site. The number of bags installed will be confirmed and will match the number required on the coverage chart. In addition, a coverage chart must be posted on the jobsite. A copy of the insulation certificate must be included in the job file (SWS 4.1005.2d)

Roof leaks will be repaired before performing attic air sealing or insulation. Major roof leaks may require deferral. Moisture sources in the house that can generate moisture into the attic will be identified and removed or reduced if possible. Where possible, water resistant sealants and/or closed cell foams will be used. In marine climates, vapor permeable materials will be used to block and seal penetrations in attic.  
(SWS 2.0401.1a)

- 1.02** Subfloor or drywall will be removed to access cavities as necessary, including inaccessible knee-wall attic floor spaces. (SWS 4.1005.1a-.2a)
- 1.03** Insulation will be adequately marked for depth a minimum of every 300 square feet of attic area, with measurement beginning at the air barrier.  
(SWS 4.1005.1a-2a)
- 1.04** Increase the attic insulation to a minimum of R-38 or the maximum allowable depth available. Depending on the weight of the material to be installed, allowances shall be made for compression of the existing material to ensure a final minimum value of R-38. (SWS 4.1005.2)
- 1.05** The installer is responsible for determining that the ceiling system is structurally adequate to support the additional insulation and load before installation. The installer shall be responsible for repair of ceiling damage during the installation of the ceiling insulation and associated work.

**1.06 Air Sealing:** All bypasses and penetrations must be sealed prior to insulation being installed. Sealing methods may vary and shall include but not be limited to the following locations: top plates of interior wall partitions, housing of exhaust fans and recessed lights; soil vent stacks and plumbing vents; duct work that penetrates the ceiling; electrical light boxes, wiring penetrations, clothes chutes, dumb waiters, and pocket doors. For details on sealing attic bypasses, see Appendix C and section 6.

**1.07 Heat producing fixtures:** Solid flame-resistant enclosures shall be securely attached around all heat producing fixtures such as manufactured chimneys (i.e. Metalbestos), Type B vents, doorbell transformers, and other miscellaneous line-voltage electrical devices. Exhaust fans (without light fixtures) and exhaust fans with IC-rated fixtures are not considered heat producing fixtures and do not require shielding.

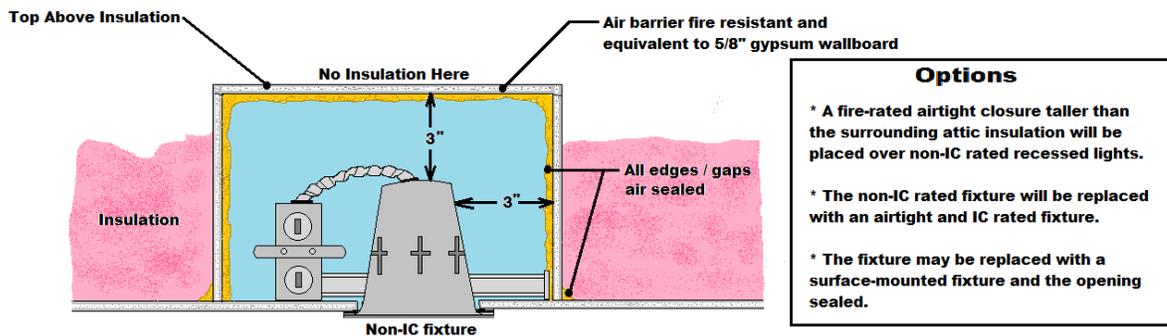
1. Shielding shall keep insulation at least 3 inches but not more than 4 inches from the sides of the fixtures. Insulation will not be allowed between a heat-generating appliance and a dam. (SWS 4.1001.3b-c)
2. Shielding shall extend at least 4 inches above the final level of insulation. (SWS 4.1001.3b)
3. Shielding material shall be non-combustible and securely attached to the building. (SWS 4.1001.3a)
4. Holes, penetrations, and bypasses around the heat producing fixtures will be sealed. (SWS 4.1001.3a)
5. If fiberglass, rock wool or other non-combustible loose fill insulation is installed in the attic space, no clearance is required around the masonry chimneys (**does not include cellulose insulation**). Non-combustible insulation is insulation material which conforms to the standard test method ASTM E136.82.



Shielded B Vent in Attic

- 1.08 Non-IC rated recessed light fixtures:** A fire rated air barrier system (i.e., equivalent to 5/8 fire code gypsum wallboard) taller than surrounding attic insulation will be placed over non-IC rated recessed light fixtures. The enclosure must be kept at least 3 inches away from the top, sides including wiring, box and ballast of any fixture. The top of the rigid barrier enclosure must be air sealed with non-insulating rigid material (e.g. gypsum or equivalent perm rating and R-value). The top enclosure material will be an R-value of 0.56 or less and must be left free of insulation. Caulk, mastic, or foam will be used on all edges, gaps, cracks, holes, and penetrations of closure material. (SWS4.1001.1a-b). Or the weatherization agency may choose from one of the following:
- The non-IC rated light fixture will be replaced with an airtight IC-rated fixture or insert.
  - The fixture(s) may be replaced with a surface mounted fixture and opening sealed.

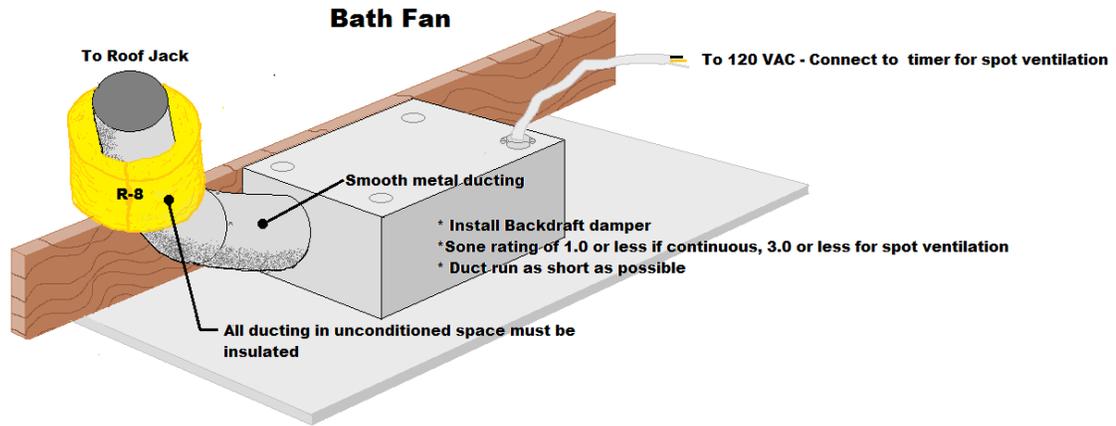
### Non-Insulation Contact (IC) Recessed Light



**1.09 Baffles for Eave and Soffit Vents:** Eave and soffit vents shall be baffled to prevent air movement through the insulation and blockage of the vent; all insulation types shall comply with this requirement. Baffles shall maintain an opening equal to or greater than the size of the vent. Baffles shall be fastened to roof rafters with no less than 9/16 inch galvanized staples or roofing nails. Baffles shall be rigid and air impermeable. All baffles shall extend at least 4 inches above the final level of insulation. Where a continuous soffit vent exists, baffles shall be installed equally spaced along the length of the soffit and allow sufficient Net Free Area (NFA) of ventilation. Baffle shall be installed far enough into the bay to reach the exterior side of the top plate. (SWS 4.1001.4a & 4.1088.1d)

### 1.10 Exhaust Fans

Bathroom and other exhaust fans, may vent through the attic space with a direct connection to the outside. The recommended method for ducting exhaust fans is to run the duct directly through a roof jack using rigid metal ducting. Use of existing roof vents is acceptable as long as attic ventilation requirements are maintained. If a convenient roof vent does not exist, one shall be added.



1. The run shall be as short as possible. Exhaust fans shall be equipped with an operating back-draft damper.
  
2. Duct will be connected and sealed to termination fitting as follows:
  - a. Round metal-to-metal will be fastened with a minimum of three equally spaced screws.
  - b. Other metal-to-metal connections will be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, or tapes.
  - c. Other specialized duct fittings will be fastened in accordance with manufacturer specifications.
  - d. In addition to mechanical fasteners, duct connections will be sealed with UL 181B or 181B-M listed material.
  - e. Fasteners will not inhibit damper operation.  
(SWS 6.6002.2c)
  
3. Kitchen range exhaust fans shall be connected with a manufactured duct of not less than 26 gauge galvanized sheet metal, substantially airtight to the outside (i.e. use of roof jack or other positive connector) and extended vertically, directly into a code-approved metal vent cap. This duct shall

have no horizontal or 90 degree bends and shall be installed to meet all local building codes. (SWS 6.6002.2g)

4. A termination fitting with an integrated collar will be used. The 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. (SWS 6.6002.2b)
5. Termination: Screen material with no less than ¼ inch and no greater than 1/2 inch mesh size in any direction will be used. The termination must be a minimum of 3 foot away from any property line, a minimum of 3 foot away from operable opening to the interior of the home and a minimum of 10 foot away from any mechanical intakes. (SWS 6.6002.2e-f)
6. Bathroom exhaust fans (that do not contain lights or heat lamps) are not heat producing fixtures and do not require shielding.
7. Replacement fans to be used as local ventilation shall have a Sone rating of 3.0 or less. Fans intended to be used for whole building ventilation, whether continuous or on an intermittent cycle, must have a sone rating of 1.0 or less. (SWS 6.6288.1a-b & 6288.2a-b)
8. It is acceptable for an exhaust fan to be connected to a light.
9. All fan exhaust ducts installed outside of the conditioned space must be insulated to a minimum of R-8. (SWS6.6002.1b)
10. Exhaust ducts will be supported by 1/2 inch or wider 18-gauge strapping or 12 gauge or thicker galvanized wire no less than 10 feet apart. (SWS 6.6002.1c)



### 1.11 Knob and Tube Wiring

1. Knob and tube electrical wiring is often found in the walls and attics of older homes. The possibility that insulation may trap heat produced by overloaded knob and tube wiring circuits requires insulation shall be kept 3 inches away from any live knob and tube wiring. Depending on agency policy, Oregon Building Code allows insulation to be installed over, around or in contact with knob and tube wiring if the following conditions are satisfied. (Article 394, 2011 Oregon Electrical Specialty Code). Contractor, assessor, auditor, or similar will inspect and assess the house to identify knob and tube wiring. Non-contact testing method will be used to determine if knob and tube wiring is live. (Variance SWS 2.0601.1a-c, 4.2001.2a-c)

When active knob & tube wiring is present, a warning sign must be posted at all entries to the attic indicating the presence of knob and tube wiring. (SWS 2.0601.1c, 4.2001.2c)



Non-Contact Testing of K&T Wiring

2. If knob and tube wiring exists in an attic space and is known to be dead then the wiring may be covered by insulation.
3. A licensed journeyman electrician or certified electrical inspector shall inspect and certify wiring to be safe. This includes repairs, alterations or extensions to the electrical system. (SWS 2.0601.1c, 4.2001.2c)
  - a. All defects found during the inspection shall be repaired prior to the installation of insulation.
  - b. All knob and tube circuits shall have over-current protection in compliance with the 60°C column of Table 310-16 of National Fire Protection Agency (NFPA) 70-1 990. Over-current protection shall be 15 amp circuit breakers or Type S fuses. The Type S fuse adapters shall not accept a fuse of an ampacity greater than that permitted in this chapter.
4. Fiberglass and cellulose insulation are acceptable for use in contact with **approved** knob and tube wiring. Foamed-in place insulation shall not be used with knob and tube wiring.
5. Non-soldered exposed splices or connections shall be protected by installing solid flame resistant enclosure, securely attached with at least 3 inches clearance from insulation.
6. When existing knob and tube wiring will not be upgraded, it shall not be covered. (SWS 2.0601.1c, 4.2001.2c)
  - a. It is allowable to insulate below the knob & tube wiring with nothing above. An unfaced fiberglass batt of highest R-value possible shall be placed under the knob and tube wiring.
  - b. To maintain a minimum 3 inch air space to the sides of the knob and tube wiring. A dam shall be created using unfaced fiberglass batts at least 14 1/2 inches in width and equivalent to an R-38 to prevent attic insulation from covering the knob & tube wiring.
  - c. The balance of the attic may be blown to full insulation depth. Taking precautions not to cover any protected knob & tube wiring.

### 1.12 Electrical Junctions

Open electrical junction boxes must have covers installed. Junction boxes that are inaccessible from the inside of the home must be flagged to be seen above the level of the insulation. (SWS 4.1005.1-.2)

### 1.13 Vapor Retarder

1. If vapor retarder is installed with ceiling insulation, the retarder shall be placed between the insulation material and the conditioned living space. Vapor retarder shall not be installed over the top of existing insulation.
  - a. Slashing of vapor retarder on new insulation is prohibited. Install unfaced insulation or remove the facing if necessary.
  - b. If existing insulation has an attached retarder that is reversed, this retarder shall be slashed before new insulation is installed.

### 1.14 Loose Fill Insulation

1. Loose fill insulation shall be level and smooth with uniform R-value throughout and not sloped at the eaves. The only exception is in attics with very low pitches, where the roofline and venting prevents adding the full-required depth of insulation. All insulation will be installed to the depth indicated on the manufacturer coverage chart for desired R-value. (SWS 4.1005.2c)
2. Attic air sealing shall be performed when installing additional insulation in attics and rakes. For critical details on air sealing attics, see section 6 and Appendix C.



Sealing of a chimney chase way



Knee wall blocks needed before insulating

3. Insulation levels shall be maintained to the full amount over heated areas wherever space permits. Dams or sloping insulation over unheated areas such as garages and covered patio/porches are options.
4. Dams may consist of batt insulation with an R-value to that specified for the ceiling and at least 14 1/2 inches wide. If batt insulation is used, the batts shall be placed flat around the perimeter of the ceiling. Dams shall be securely attached to the framing and in complete contact with the air barrier.

#### **1.15 Batt or Blanket Insulation**

1. The blanket or batt insulation must completely cover the top plate of the exterior wall.
2. The blanket or batt shall fit tightly together with no gaps, Batt insulation will be installed in accordance with manufacturer specifications without gaps, voids, compressions, misalignments, or wind intrusions except those required for clearance around heat-producing fixtures. The blanket or batt shall be installed without overlapping or unduly compressing the insulation.  
(SWS4.1005.3c)
3. Insulation shall retain the full R-value after the installation of batt or blanket insulation. The insulation shall be level and smooth throughout the attic space except over ducts.
4. If no insulation exists, two layers of batts may be used. The first layer of batts may have a vapor retarder facing towards the conditioned living space. The second layer of batts shall be unfaced and shall run perpendicular with the first layer. If an attic contains knob-and-tube wiring, the two layers of batts can be installed parallel with each other but with the seams and joints staggered to not have any seams or joints from the bottom layer exposed to the vented attic area. (See Section 1.11)

#### **1.16 Attic Ventilation**

1. Installation of additional attic venting is allowed, but not required. Attic ventilation should be part of an overall strategy for controlling attic air temperatures and should be considered an optional measure. Attic ventilation will be recommended or installed only if the presence of an

effective air barrier and the thermal boundary between the attic and the living space is verified using pressure diagnostic techniques and appropriate attic sealing and proper insulation is specified as part of the work scope.

(SWS 4.1088.1a)

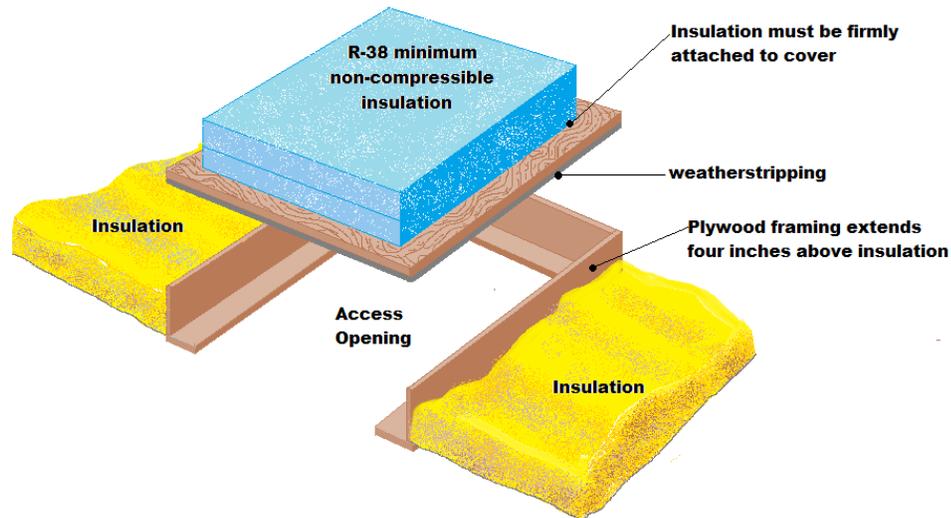
2. All vents shall be installed according to the manufacturer's recommendations.
  - a. Vents shall be installed to cover the entire opening,
  - b. Vents shall be securely attached and sealed if necessary.
  - c. Roof tar is unacceptable when using plastic roof vents.
3. Vents shall not be restricted with roof rafter/joists or enclosed soffit vents, etc.
4. Attic vent types will be made of corrosion-resistant material for their specific location (e.g., exterior soffit, gable end, roof) and material and intended use (e.g., metal vent on metal roof). (SWS 4.1088.1b)
5. Only the net free area of the openings for rotating air turbines may be considered for calculating ventilation.
6. Vents should be installed in an equally spaced manner. Cross ventilation is preferred.
7. Attic power ventilators will not be used. (SWS 4.1088.1b)

All attic ventilation will have screens with non-corroding wire mesh with openings of 1/16 inch to 1/4 inch to prevent pest entry. (e.g., birds, bats, bees) (SWS 4.1088.1e)

### 1.17 Attic Access

1. Attic access openings shall be protected from having loose fill insulation fall through the opening.
  - a. 14 1/2 inches or wider insulation batt with an R-value equal to that specified for the attic may be placed tightly around the perimeter of the access opening.
  - b. A Rigid dam such as 1/2 inch plywood or similar material, permanently attached, extending above the final level of the insulation must be installed

around all attic accesses. If clearance prohibits the use of a rigid dam, a fiberglass dam may be used. (SWS 3.1001.9e & 4.1006.2a)



2. Horizontal and vertical openings into the attic shall be insulated to the same level required for the wall or ceiling: R-38 for horizontal openings and R-21 for vertical openings. Insulation shall be non-compressible, permanently attached and shall entirely cover the access.  
(SWS 3.1001.9g-f & 4.1006.2a-c)
  
3. Access doors, which incorporate retractable ladders or similar devices, shall be insulated. This shall be accomplished by installing an insulated cover over the opening in the attic. The entire pull-down stair assembly will be covered with an airtight and removable/openable enclosure inside the attic space.
  - a. Pull-down stair rough opening will be surrounded with a durable, air tight dam that is higher than the level of the attic floor insulation.  
(SWS 4.1006.1a & 1b)
  
  - b. The removable cover will be insulated with non-compressible insulation and the measure will include a protective barrier or baffle. The cover

over the pull-down stair assembly will be insulated to the same R-value as the adjoining insulated assembly. (SWS 4.1006.1a)

- c. Pull-down stair frame enclosure will be caulked and the cover must be weatherstripped. The weather-stripping shall be closed cell foam tape and shall be permanently attached to hold it in place for the life of the structure. The separation between the interior and exterior environments of a building that slows air flow to the point that no smoke movement is visible at 50 Pascals of pressure difference across the boundary material. (SWS 4.1006.1b)
4. Attic access doors shall be made substantially airtight by installing framing, caulking around framing and weather-stripping. The weather-stripping for horizontal openings shall be closed cell foam tape and shall be permanently attached to hold it in place for the life of the structure. Install latch, if needed, to ensure tight closure. (SWS 3.1001.9e & 4.1006.2b)

#### **1.18 Water Pipes**

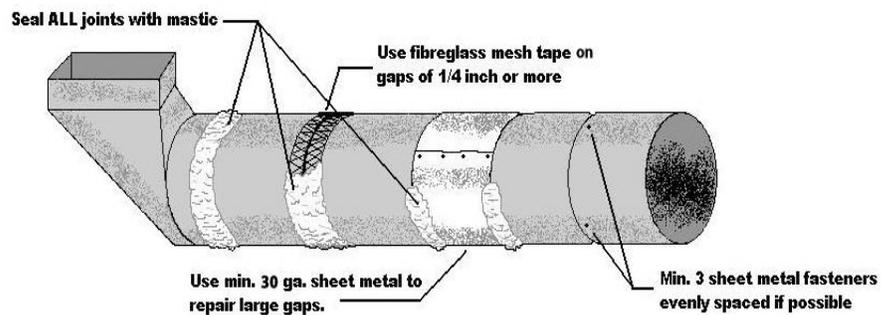
1. All exposed water pipes after insulation is installed in attic spaces shall be insulated to R-3 with pre-split tubular foam or a minimum R-11 unfaced fiberglass batt. The pipe insulation shall be installed in accordance with Specification 3.10.
2. All exposed water pipes in the attic shall be covered with a minimum of 3 inches of insulation or separately wrapped to meet water pipe specifications.

#### **1.19 Heating Ventilation and Air Conditioning Ducts (HVAC)**

1. Metal HVAC ducts located in the rake or attic areas shall be sealed and insulated to a minimum of an R-19. The insulation under and around the duct shall be equivalent to the ceiling insulation required with a minimum of R-19 on top of the duct. Seal ducts prior to installing attic or rake insulation. If the attic is being insulated with loose fill insulation that could fall off the duct, which is common with ducts larger than 8 inches in diameter, separate duct insulation shall be installed. If clearance is limited the highest attainable R-value shall be installed. See section 5 for critical details on sealing and insulating metal ductwork. (SWS 4.1601.2a)

2. All existing flexible ducting will have a minimum of R-8. All flexible ducting less than an R-8 should be replaced with metal duct, sealed and insulated to a minimum of R-19. In cases where metal duct cannot be installed, flexible ducting of a minimum of R-8 may be installed. All exposed metal fittings must be insulated to a minimum of R-19. See section 5 for details on flexible duct installation. (SWS 4.106.1a & b)

## Ducts



### 1.20 Knee Wall Attic

1. Knee walls adjoining attic spaces shall be insulated to a minimum of R-21. Insulation shall be installed in accordance with the specifications for unfinished walls. See Section 2.09



Batt Insulation

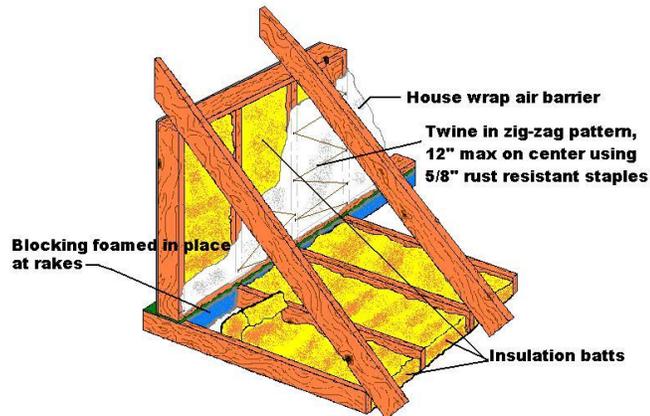


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## Knee Wall



2. Air leaks in knee wall attics shall be thoroughly sealed using a rigid material to reduce air movement and water vapor leakage. (See Section 6 for air sealing information and Section 2.09 for knee wall installation requirements.) (SWS 4.1004.2a)



Knee wall block, rigid board insulation secured with foam

3. Blocks must be installed at the base of the knee walls to prevent air movement. (SWS 4.1005.5a)
4. Insulating floored attic areas:
  - a. Attic spaces with floors shall be insulated to the recommended level or highest practical R- value. Access holes not less than 1 inch in diameter shall be drilled in each joist cavity.
  - b. Each cavity will be 100 percent filled to consistent density:  
Cellulose material will be installed to a minimum density of 3.5 pounds per cubic foot.

Loose fiberglass material will be installed and will be specifically approved for air flow resistance to a minimum density of 2.2 pounds per cubic foot or per manufacturer's specification. (SWS 4.1005.5a-b)

- c. If the floored attic area will be used for storage, wooden plugs of appropriate size shall be installed in the holes after the insulation process is complete. If additional insulation is to be installed on top of the floored area, then no plugs are needed.
5. Sloped ceilings must be insulated where practical. Airflow may be maintained over the sloped ceiling insulation by using a rigid barrier that will not be compressed when installing dense packed insulation. (e.g.- polycarbonate or vinyl corrugated panels); or the sloped ceiling area may be insulated to the full cavity depth where local codes allow, provided containment materials used at the lower and upper cavity openings allow for rapid vapor diffusion.

Using a fill tube, 100 percent of each cavity will be filled to a consistent density.

Cellulose material will be installed to a minimum density of 3.5 pounds per cubic foot.

Loose fiberglass material will be installed and will be specifically approved for air flow resistance to a minimum density of 2.2 pounds per cubic foot or per manufacturer's recommendation.

(SWS 4.1005.5a-b, 4.1003.2a)

### 1.21 **Skylight Chases**

1. Skylight chases shall be treated like an unfinished wall in a knee wall attic. Insulation shall be R-21 (R-13 if space is limited), be covered with house wrap, and supported with twine. Particular attention should be paid to sealing air leaks and insulating corners at the top chord of the truss. Insulation will be installed in accordance with manufacturer specifications and will be in full contact with all sides of existing cavity without gaps, voids, compressions, misalignments, or wind intrusions. (SWS 4.1088.3a-b)

### 1.22 **Site Built Exterior Roof Insulation**

1. Existing roof covering will be removed. (SWS 4.1002.1a)

2. Holes, gaps, and penetrations in existing roof deck will be sealed (SWS 4.1002.2a)
3. Exterior roof insulation shall be a minimum of R-20 or the highest R-value approaching R-20 that is practical while maintaining the requirements of this specification. (SWS 4.1002.2b)
4. Insulation shall be in rigid board form (e.g. rigid polystyrene or polyisocyanurate insulation). A fire-rated barrier equivalent to 1/2 inch or greater plywood sheathing, edge supported (no exposed joints between sheathing) shall be installed between the insulation and the inside space. 2 inch tongue and groove decking or 1/2 inch taped gypsum board equals or surpasses this requirement.
5. Insulation will be installed according to manufacturer specifications without gaps, voids, compressions, misalignments, or wind intrusions. (SWS 4.1002.2b)
6. If no vapor retarder exists, one with a perm rating of 1 or less shall be installed between the insulation and the heated space. However, if insulation is already present in the roof system, then a vapor retarder shall not be installed.
7. The installer shall contact the agency at least 48 hours in advance to request an in-progress inspection during the installation.
8. New roof covering will be installed in accordance with manufacturer specifications and local building code requirements after installation of above roof deck insulation. (SWS 4.1002.1b)
9. Other methods of installing exterior roof insulation shall be approved by the agency in writing prior to beginning the work.

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## Section 2 : Wall Insulation

- 2.01 General:** Material shall be installed according to the provisions of current Oregon Building Code or other applicable codes and shall meet the requirements of the agency weatherization program. Any exceptions shall be approved in writing in advance by the agency. Upon completion of weatherization work, a signed and dated insulation certificate indicating square footage insulated, R-value installed, type of insulation and bag count shall be posted at the job site. The number of bags installed will be confirmed and will match the number required on the coverage chart. (SWS 4.1102.1d)  
In addition, a coverage chart must be posted on the jobsite. A copy of the insulation certificate must be included in the job file.
- 2.02** Lead and asbestos safety procedures must be followed where applicable. (SWS 4.1101.2a)
- 2.03** Walls shall be insulated to the highest R-value practical (this shall include above windows) with a minimum of R-13 in 4-inch cavities with R-21 in 6-inch cavities preferable. Insulation may be installed in wall cavities, which have R-7 or less of existing insulation and in cavities less than 3-1/2 inches thick, depending upon the agency recommendations and cost effective screening requirements. Any existing voids should be filled.
- 2.04** Holes and Penetrations
1. Holes and penetrations on exterior surface of exterior walls will be sealed with appropriate materials to ensure resistance to outdoor elements.
  2. Intentionally ventilated walls will not be sealed at vent locations (e.g., weep holes).
  3. Holes and penetrations on the interior surface of exterior walls will be repaired.
  4. Backing or infill will be provided as needed to meet the specific characteristics of the selected sealant and the characteristics of the penetration.
  5. All accessible holes and penetrations in top and bottom plates will be sealed. (SWS 4.1102.1a, 3.1101.1b, c, 3.1101.2b, c)

## 2.05 Blown in Wall Insulation

1. Access to exterior wall cavities will be gained; sheathing will be drilled as needed and probed to locate each cavity, wall studs, and blockers.  
(SWS 4.1101.1a & 4.1101.2a)
2. Interior will be masked and dust controlled during drilling when accessing from interior. See Appendix G for specifics on completing an interior access.  
(SWS 4.1101.1a)
3. Insulation shall **not** be installed in wall cavities which:
  - a. Serve as air ducts for heating, cooling or ventilation and electrical service boxes.
  - b. Contain electric space heaters unless fire stops are present or installed which isolate the heater from all contact by the insulation material. Verification of this shall be accomplished by removal of the heater prior to the installation. (SWS 4.1101.1a )
  - c. Contain active knob and tube wiring unless corrective action is taken per section 1.11 of these specifications.
4. The installer shall perform a thorough visual inspection of the walls and other areas that will be insulated from the interior and exterior to ensure integrity before blowing insulation. Drilling hazards (e.g., wiring, venting, fuel piping) will be located. Cavities will be free of hazards, intact, and able to support dense pack. If problems are discovered so that insulation cannot be installed, the installer must notify the agency before commencing work. The installer is responsible for any damage that occurs as the result of blowing walls.  
(SWS 4.1101.1a)

## 2.06 Blown in Cavity Insulation:

1. Whenever possible, insulation will be installed into cavities from the exterior side of the wall. When feasible, exterior cladding at the insulation access point will be removed before creating an access hole through the sheathing. The insulation access point will be created to minimize air barrier and drainage plane disruption. The access point will be sealed to be airtight and watertight after insulation installation before reinstalling the exterior cladding. (SWS 4.1103.4d). Siding and shingles shall be removed and reinstalled in a professional manner. Broken siding or shingles occurring during the insulation process shall be replaced, painted, or primed at the installer's expense. For techniques on removing various siding types see Appendix F.
2. If new siding must be installed, new siding will be installed in accordance with manufacturer specifications and local codes after exterior wall insulation is installed. (SWS 4.1101.2b)
3. It is allowable but not required, to remove cement/asbestos siding to install wall insulation as long as precautions are taken to prevent damage to the siding. Drilling, cutting or sanding of the siding is not allowed. Cement/asbestos siding is not considered friable. If asbestos siding is going to be removed, inform the client that suspected asbestos siding is present and how precautions will be taken. Workers removing siding must be trained in proper removal and replacement of siding.





4. Dense pack insulation: see Appendix E for techniques in blowing high-density wall insulation. Using fill tube, 100 percent of each cavity will be filled to a consistent density. High density wall insulation is defined as installing cellulose insulation at 3.5 pounds per cubic foot or fiberglass at 2.5 pounds per cubic foot. Fiberglass used for dense packing walls must limit maximum air permeance to 3.5 cfm/ft<sup>2</sup> measured using BPI -102 “Standard for Air Resistance of Thermal insulation Used in Retrofit Cavity Applications” or ASTM C522, E 283, or E 2178. (SWS 4.1103.1a, b & 4.1101.5b)
  
5. Before blowing high density wall insulation, a blowing machine pressure test will be performed by the installer with air on full, feed off, agitator running, and gate closed. Hose outlet pressure will be at least 80 inches of water column or 2.9 pounds per square inch for cellulose insulation; for other types of dense pack, check manufacturer specification for blowing machine set up. (SWS 4.1003.15c, 4.1101.1a & 4.1101.5a)



6. Insulation density will be verified by any or all of the following methods:
  - Bag count from the insulation certificate.
  - Core sampling.
  - Infrared camera with the blower door at 50 pascals.
  - Using Chemical smoke at 50 Pascals of pressure difference.  
(SWS 4.1101.1b & 4.1101.5b)
7. The agency shall determine access to the wall cavities and other areas. The installer may gain access to other areas in a different manner if approved by the agency; drilling directly through the existing interior gypsum board, lath and plaster, stucco and other material finishes which are similar in texture. This procedure shall have prior approval from the homeowner before work commences.

## **2.07 Areas for Dense Pack Insulation**

1. To assure positive quality control, the installer may be required to notify the agency a minimum of 48 hours in advance when dense pack insulation is being installed so that an in-progress inspection may be conducted.
2. Special attention shall be given to thermal bypass areas to ensure a tight thermal envelope. These spaces include but are not limited to corners, kitchen and bathroom soffits, pocket doors, intersection of partition walls, walls where plumbing is present, and inside corners of firewalls.
3. Exterior wall plugs shall be made of material that will not shrink or expand beyond the design of the siding, resulting in damage to the siding or finish (i.e. wood or Styrofoam™). Plugs shall not be of the vented type (i.e. button vents).



4. If the installer accesses the wall cavity by removing the siding or shingles, the installer shall install an appropriate size plug and re-install the siding or shingles.
5. If the drill and fill method is used by the installer, the plugs shall be recessed into place so the outer surface of the plug is below the surface of the siding. The plug shall be covered with an outdoor spackling. The spackling shall have at least one-coat primer paint after being installed. (SWS 4.1103.4e)

## **2.08 Open or Unfinished Wall Insulation**

1. Open or unfinished walls to be insulated shall be located between unconditioned and conditioned living spaces to qualify for insulation.
2. Holes and penetrations
  - a. All holes and penetrations on exterior surface of exterior walls will be sealed with appropriate materials to ensure resistance to outdoor elements if applicable.
  - b. All holes and penetrations on the interior surface of exterior walls will be repaired.
  - c. Backing or infill will be provided as needed to meet the specific characteristics of the selected sealant and the characteristics of the penetration.
  - d. All accessible holes and penetrations in top and bottom plates will be sealed. (SWS 4.1102.1a, 3.1101.1 b-c, 3.1101.2 b-c)
3. Insulation will be installed in accordance with manufacturer specifications without gaps, voids, compressions, misalignments, or wind intrusions. (SWS 4.1102.1b)
4. If insulation is being installed, a vapor retarder shall be present or installed towards the conditioned side of the wall. All batt insulation shall be installed in substantial contact with the conditioned wall. Batt insulation shall be faced after stapling.

5. Insulation exposed to living areas or routine pathways of human contact shall have a cover that has an American Society of Testing and Materials (ASTM) flame-spread rating of 25 or less, i.e. house wrap, FSK, or 1/2 inch sheetrock. If the insulation is to be covered with sheetrock, verification of complete installation without gaps, voids, compressions, misalignments, or wind intrusions will be confirmed either by an in-progress inspection or photo documentation provided by the installer. (SWS 4.1102.1c)
6. Insulation shall be cut to fit snugly in each cavity. Insulation shall be cut or slit to fit around wiring or plumbing and electrical boxes in wall cavities. It shall not be compressed behind or around protrusions.

## **2.09 Knee / Pony Walls**

1. When insulation is added to the knee wall where none exists, all penetrations through the wall shall be sealed with caulk or foam prior to installing the insulation. This would include the gap between the rough opening and the access opening of the knee wall or the pony wall. If the knee wall has existing insulation, then as much air sealing as possible should take place on the interior of the wall.
2. When a pony wall is being insulated, all penetrations shall be sealed before insulation is installed. Sealing of penetrations shall also include the floor joists at the top of the pony wall. The floor joist cavity area shall be sealed by installing the same size wood framing, (polyisocyanurate, or extruded polystyrene) as the floor joist, and nailed/caulked in place. The pony wall insulation would be installed from the sub-floor to the bottom plate. (SWS 4.1102.1a)
3. The wall shall be insulated to minimum of an R-21 when using batt insulation. Insulation shall fit tightly against the top of the wall, and the vapor retarder shall be installed against the conditioned side of the wall. The insulation shall completely fill the cavity and be in substantial contact with the conditioned wall without gaps, voids, compressions, misalignments, or wind intrusions. (SWS 4.1102.1b)

4. An air barrier i.e. house wrap shall be installed on the unheated side of the wall. The air barrier shall completely cover the insulation. (The air barrier is required to prevent wind washing.)
5. Support twine shall have anchor points in a zigzag pattern spaced no greater than 18 inches on center. The twine shall be anchored at every point at which it crosses a stud. This specification shall apply to existing insulation, as well as new insulation.
6. When woodstove, water heater or furnace flue pipe penetrates the wall, sealing the flue pipe to the wall shall be performed in accordance with local building codes. Only noncombustible sealant will be used in contact with chimneys, vents and flues. (SWS 3.1102.1d)
7. When blowing knee wall cavity with loose fill insulation:
  - a. The entire wall surface shall be covered with a suitable air barrier; i.e. house wrap.
  - b. The cover shall be secured with 1 inch wide crown staples every 2 inches or with furring strips every wall stud. Staples shall penetrate at least 5/8 inch into framing members (SWS 4.1004.1a)
  - c. The air barrier shall be cut in an "X" pattern in each cavity.
  - d. Insulation that is blown behind an air barrier material will be blown dense to a minimum specification of 3.5 pounds per cubic foot for cellulose or fiberglass at 2.5 pounds per cubic foot. (SWS 4.1004.1b)
  - e. All penetrations in air barrier shall be sealed with an approved air barrier seam tape.
8. Wall accesses shall be insulated to R-21 or greater. Insulation shall be non-compressible, permanently attached and shall entirely cover the access. (SWS 3.1001.9g-f & 4.1006.2a-c)
9. Wall access doors shall be made substantially airtight by installing framing, caulking around framing and weather-stripping. The weather-stripping for horizontal openings shall be closed cell foam tape and shall be permanently attached to hold it in place for the life of the structure. Install latch, if needed, to ensure tight closure. All four sides of wall accesses must be weatherstripped. (SWS 3.1001.9e & 4.1006.2b)



## 2.10 Thermal Bypass Air Leakage Areas

1. Walls, cantilevered floors and overhangs (eyebrows), wall/ceiling junctures (small attics), wall/floor junctures (porches and garages), rim joists (between first and second and/or other floors); garages under living spaces and offset floors and ceilings shall be insulated utilizing the high density method.
2. Cantilevered floors, commonly referred to as “bumpouts” that have open cavities can be insulated with an appropriate size Kraft-faced fiberglass batt and covered with exterior grade plywood or primer painted plywood. It shall be sealed and caulked.

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## Section 3 : Underfloor

- 3.01 General:** Material shall be installed according to the provisions of current Oregon Building Code or other applicable codes and shall meet the requirements of the agency weatherization program. Any exceptions shall be approved in writing in advance by the agency. Upon completion of weatherization work, a signed and dated insulation certificate indicating square footage insulated, R-value installed, type of insulation and bag count shall be posted at the job site. In addition, the coverage chart off of the insulation bag must be posted on the jobsite. A copy of the insulation certificate must be included in the job file. (SWS 4.1301.1d, 4.1301.2d)

A durable, easily seen sign must be installed at all accesses inside of the crawlspace. The sign must warn those entering the crawlspace not to damage the air barrier, ground moisture barrier, insulation, and mechanical components. The sign must contain the installer or agency contact information in case repairs are needed. Additionally, the sign must contain language prohibiting storage of hazardous or flammable materials in the crawlspace. (SWS 2.0701.2a-c)

At completion of the project, the occupants must be given documentation in either written or electronic form that describes components of the system, maintenance requirements, and health and safety considerations at a minimum. When possible, the documents must be reviewed with the occupants. Occupant/Landlord must be given contact information for installation company and warranty information. (SWS 2.0702.1b-c)

Before air sealing basement or crawlspace walls near wet areas, surface water pooling near the foundation or standing water in the crawlspace must be addressed by repairing, modifying, or replacing gutters and downspouts, grading and subsurface drainage at critical locations, sump pumps etc. Any drainage repair issues must be treated as an incidental repair. Major drainage issues are beyond the scope of the program. (SWS 2.0401.1d, 2.0402.1a-e)

- 3.02** Insulate underfloor areas to a minimum of R-25 over unheated crawlspaces, unused cellars, and unconditioned basements. With some floors, it may be less expensive to install a thicker batt to fill the cavity rather than devising a support system for thinner batts.

- 3.03** The agency may require that a dry rot inspection be performed before floor insulation is installed. If dry rot is discovered, the installer should stop work and report it immediately to the agency. The agency may decide to drop the measure or pay for repairs. Repairs shall be made prior to installing insulation.

If any wet areas of the sub-floor or wood-supporting members are found, the agency shall be notified immediately and the source of the moisture shall be eliminated. Wet areas shall be dried before floor insulation is installed.

- 3.04** All insulation shall be in substantial contact with the sub-floor to eliminate the possibility of creating a fire chase way and to prevent convective heat loss



- 3.05** Insulation shall be cut to fit each joist space. All ends shall fit tight without overlapping. Insulation shall fit tight against structural members, rim joists, foundation walls, and pipes with no gaps.

- 3.06** When fiberglass batts are used in the underfloor, the facing material shall be in substantial contact with the sub-floor without gaps, voids, compressions, misalignments, or wind intrusions and the insulation shall remain attached to the faced material. The facing on batt insulation installed in cavities shall be stapled to the underfloor using 18-gauge 5/8-inch long corrosion resistant staples. Faced batts shall be adequately attached to support the insulation prior to twining. Unfaced insulation can be installed where vapor retarder exists in the floor system itself. Vapor retarders shall have a perm rating of 1.0 or less and shall be located between the insulation material and the conditioned living space. Unfaced batts may be allowed at the agencies discretion. (SWS 4.1301.1b)

- 3.07** All exposed, uninsulated heating and air conditioning HVAC ducts located in crawlspaces, cellars, and unheated basements shall be sealed and insulated as per section 5.

### 3.08 Using the blown-in fiberglass method (BIF) method:

1. All penetrations shall be sealed prior to installing insulation. (SWS 4.1301.2a, 2.0401.1b)
2. The entire floor surface shall be covered with a suitable air barrier; i.e. Tyvek™ or equivalent product. Air barrier used must meet local fire codes. (SWS 4.1301.2b)
3. Support the air barrier with twine attached at every point it crosses a stud. Attaching twine shall not exceed 12 inches on center. (SWS 4.1301.2d)
4. Twine shall be installed in a zigzag pattern not to exceed 12”.
5. 5/8-inch staples of at least 18 gauge corrosion resistant materials shall be used to attach twine.
6. The air barrier shall be cut in an “X” pattern in each cavity.
7. Approved insulation installed must be dense packed with loose fill insulation in accordance with manufacturer specifications.
8. All penetrations in air barrier shall be sealed with an approved air barrier seam tape after insulating is complete.

### 3.09 Air Sealing

1. All combustion flue penetrations shall be sealed using appropriate non-combustible material. (SWS 3.1402.1c)
2. Combustion air supplies must be labeled for identification and must **not** be blocked or sealed. (SWS 3.1301.1d)
3. Sealing of all other penetrations through the floor shall be included in all floor insulation work. Particular attention is necessary under bathtubs, shower stalls, heating registers, and where plumbing or wiring penetrates the floor. (SWS 2.0401.1b)
4. Backing material must be provided on larger penetrations. The backing material must not sag after installation. (SWS 4.1301.1a)

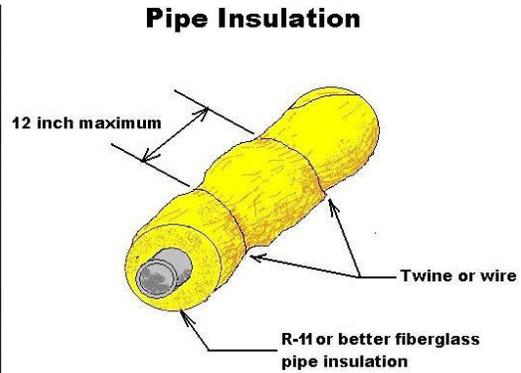
5. Sealants used must be compatible with the intended surfaces and must allow for expansion of dissimilar materials. (SWS 4.1402.1 a-b)



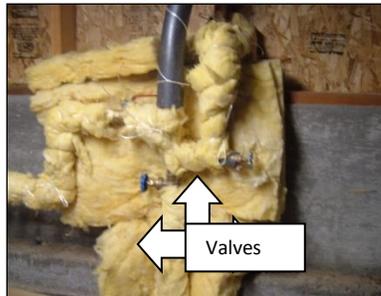
Plumbing penetration sealed

### 3.10 Pipes

1. Water pipes in crawlspaces insulated under the program shall be insulated with R-3 pre-split foam or R-11 vinyl covered insulation in a human contact area or where water pipes are in contact with the ground. R-11 unfaced fiberglass batts are acceptable in a non-human contact area. If required by agency, drain traps shall also be insulated using R-11 unfaced batts. (SWS 7.8104.3d)
2. Before installation, the installer shall ensure pipes are in satisfactory condition to receive insulation, are free from water leaks, and are properly secured to support the weight of the pipes and insulation. If problems are found, such as leaks or improperly supported pipes, the agency shall be notified before insulating that section of pipe.
3. Pre-formed pipe 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. Wrap joints that do not fit tightly, such as T-joints and elbows, with batt insulation. Installer shall use the correct inside diameter size insulation for the pipe being insulated (e.g. it is not permissible to use 1 inch preformed pipe wrap on 1/2 inch pipe). The lengthwise slit shall be positioned on horizontal pipe so that the slit is on the bottom side of the pipe. Twine, galvanized wire, or non-slipping plastic ties shall be used to secure the insulation. The ties shall be spaced starting at 1 inch from each end of the material and thereafter approximately every 12”.



4. Water pipes insulated with unfaced fiberglass insulation shall be firmly secured to the water pipes without unduly compressing the insulation. A minimum of R-7 (or about 2 1/2 inches in depth) shall be maintained after the pipe insulation is complete. The insulation shall be secured in place by polypropylene nylon twine, galvanized wire, or non-slipping plastic ties. The securing method shall be spaced at 2 inches from each end of the material and thereafter approximately 12 inches. Use fiberglass insulation when water piping runs next to a beam or joist.



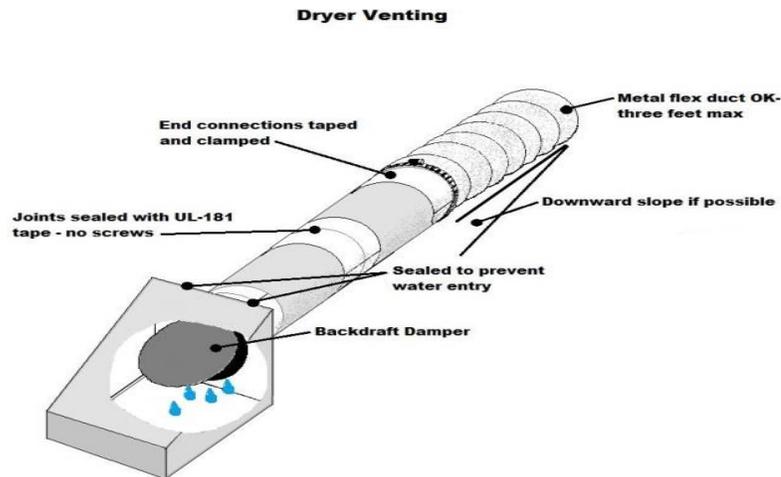
5. The location of all valves covered by insulation shall have tags hanging below the final insulation for easy location.

### 3.11 Exhaust Duct

1. Appliance exhaust vents (e.g. exhaust fans, kitchen range exhaust etc.) shall terminate outside the residence using manufactured duct and be equipped with a back-draft damper. Outside of the residence does not include unconditioned spaces such as attics and crawlspaces that are ventilated with the outdoors. Any new ducts installed under the program shall be made of rigid metal with smooth interior surfaces. Whenever possible, Ducting shall be supported with a downward slope at every connection. Bends or reversing horizontal runs in ducts shall be eliminated if possible. All exhaust ducts located in an unconditioned space must be insulated to an R-8. Kitchen range exhaust fan ducting shall meet the material standards in Section 1.10-3. (SWS 6.6005.1a)

### 3.12 Dryer Vents

1. All dryers must be vented to the outdoors and terminated with an operable dryer vent hood. Outdoors does not include unconditioned spaces such as attics and crawlspaces that are ventilated with the outdoors. (SWS 6.6005.1a)
2. The operable dryer vent hood must include a backdraft damper. The outlet must be sealed to prevent water and air intrusion. (SWS 6.6005.3c)
3. Dryer vent ductwork must be smooth surfaced, rigid sheet metal, supported at each connection in the crawlspace and vented to daylight utilizing the shortest run possible. Use of elbows should be limited to the least possible number to ensure unobstructed venting. Plastic venting is not allowed. (SWS 6.6005.1a)
4. All joints must be sealed using UL – 181 tape (metal tape). (SWS 6.0005.1a)
5. Connections to the dryer and the dryer vent hood must be secured with a clamp as well as sealed with UL 181 tape. (SWS 6.6005.1a)
6. Flexible metal vent pipe may be used between the dryer and the hard pipe connection if it does not exceed three feet in length. The connection between the flexible metal and rigid metal vent pipe must be secured with a clamp as well as sealed with UL 181 tape. (SWS 6.0005.1a)
7. Dryer vent pipe must not be installed with sheet metal screws or other intrusive fasteners that will collect lint. (SWS 6.6005.1a)
8. Whenever possible, the dryer vent must be installed with a downward slope to the outside to allow for condensation drainage.
9. Dryer vents exceeding 35 foot in length must have a dryer booster fan installed. (SWS 6.6005.1a)
10. Occupant must be instructed to keep lint filter and termination fitting clean. If applicable, occupant must be instructed to keep dryer booster fan clean, if present. (SWS 6.6005.1e)



### 3.13 Crawlspace Ventilation

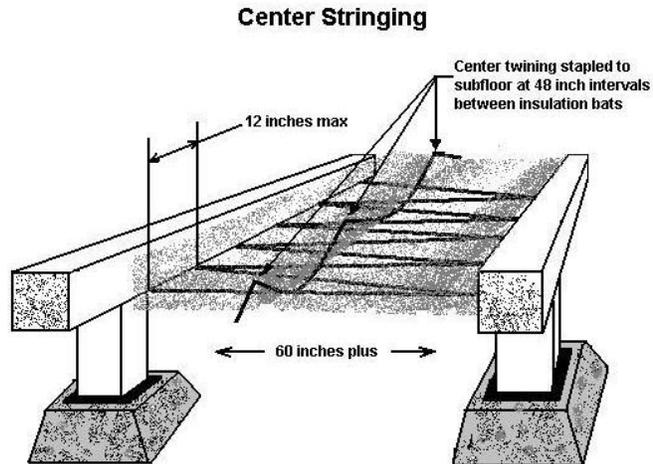
1. Underfloor areas shall be ventilated by openings in the exterior foundation walls. Openings shall be located as close to corners as practical and shall provide cross ventilation. The required area of such openings shall be equally distributed along the length of at least two opposite sides.
2. Such openings shall have a net-free area (NFA) of not less than 1 square foot for each 300 square feet of floor area, provided there is no standing water or excess moisture.
3. If there is standing water or the agency feels there is excess moisture, then the NFA, or vent openings shall be 1 square foot for each 150 square feet of crawlspace area.
4. When moisture is not an issue the venting can be 1 square foot of NFA for each 1,500 square feet as long as ground surface is treated with an approved ground cover material and the required openings are placed so as to provide cross ventilation of the space. (SWS 2.0401.2a)



5. All vents, new or existing, shall be screened with  $\frac{1}{4}$  inch corrosion resistant wire mesh attached from the inside and secured on all four sides. Code requires wood in contact with cement or ground to be pressure treated.

### 3.14 Insulation Support Systems

1. The support mechanism shall be attached at every point where it crosses a joist or beam. The maximum spacing for the support mechanism with 24 inch on center or greater floor joist spacing shall not exceed 12 inch on center. Shorter spans shall not exceed 18 inch on center. Support for floor insulation shall be provided according to one of the following methods (this applies to new and existing insulation):
  - a. Twine - polypropylene or polyester twine shall have a breaking strength of at least 150 pounds. The twine shall be installed in a zigzag, joist-to-joist pattern across each joist space. A 16-inch on center floor joist system may be zigzagged across two floor joists, but shall be stapled at every point it crosses a joist. Any joist system larger than 16 inch on center shall be stapled and zigzagged at every joist.
  - b. Center stringing: shall be used on floors where post and beam construction is 60 inches or greater on center. This is accomplished by twining the floor insulation in a zigzag pattern, securing twine to each floor joist, not to exceed 12". On a seam (where two batts join), no more than 48 inches apart, support primary twine by crossing over it and attaching to sub-floor. Center twine shall run parallel to seams in batts.



- c. Wood lath - shall be a minimum 5/16 inch by 1 inch, Number 1 grade. Individual lath shall be long enough to span the required distance. Splicing of individual lath is not acceptable.
- d. Agency approval shall be issued prior to using other support systems.
- e. “Lightning rods” are prohibited as a support system for newly installed insulation.



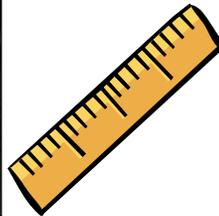
Twining under site built floors

- 2. Fasteners for lath or twine may be either hot-dipped galvanized nails or corrosion resistant staples. All fasteners shall penetrate the supporting structural member at least 5/8 inch. Staples shall be at least 18 gauge. Hand staplers or hammer tackers are not capable of providing adequate penetration of staples and are prohibited from use in this application.
- 3. Support systems for floor insulation shall not compress the insulation material more than 10 percent or otherwise alter the insulation value of the material except where necessary around the perimeter. Insulation shall be permanently supported so as not to block or restrict crawlspace ventilation. Support system shall keep insulation in substantial contact with the floor.

4. In no case shall the support of floor insulation be farther than 3 inches from the end of the batt. Added loose pieces shall not be left unsupported. Special attention shall be given to plumbing.

### 3.15 Ground Moisture Barrier

1. If a new ground moisture barrier is required per agency work order, it shall be minimum 6-mil black polyethylene or its equivalent in perm-rating, strength and resistance to soil chemical degradation.  
(SWS 2.0403.4b, 2.0403.1c, 2.0401.1b)
2. When seams exist, they must be overlapped a minimum of 12 inches using "reverse" or "upslope lapping" technique. The ground moisture barrier shall cover all earth but shall not contact any wood members.  
(SWS 2.0403.1d, 2.0403 .4c)



3. Ground moisture barrier must extend a minimum of 6 inches up the foundation wall. (SWS 2.0403.1e)
4. Ground moisture barrier must be fastened to ground with durable fasteners or ballast(s) if exposed to wind effects or the ground slope will cause movement of the ground moisture barrier. (Variance SWS 2.0403.1e)
5. 100 percent of all exposed soil shall be completely covered with no rips or tears in the cover. New cover may be placed over the old ground cover.  
(SWS 2.0403.1b, 2.0401.1b)
6. All debris, including organic material and any debris that may cause injury or puncture the ground moisture barrier, shall be removed from the crawlspace as possible, before the new ground cover is installed. Debris removed must be disposed of appropriately. (SWS 2.0107.3a –b)

### **3.16 Access Door-Outside**

1. Access to the crawlspace shall have a cover that is securely attached. Access must allow for free access to all mechanical equipment located in the crawlspace without risk of damage to the thermal barrier, air barrier or ground moisture barrier. Wood in contact with cement or ground shall be pressure treated.

### **3.17 Access Door-Inside**

1. Access doors to an adjacent conditioned space shall be insulated with non-compressible insulation to at least the R-value of the insulation being installed on that pony wall. Pony wall access doors shall be made substantially airtight with appropriate materials if they open to a conditioned space. This shall include caulking, framing (finish and rough), weather-stripping (closed cell) and the access door itself shall be repaired or a new one made if needed.
2. Inside floor accesses shall be insulated to a minimum R-25. The insulation shall be completely covered with an air barrier (house wrap, Tyvek™ or equivalent) and securely twined. The access shall be made substantially airtight by installing framing, caulking around the framing, and weather-stripping. The weather-stripping shall be closed cell foam tape and shall be permanently attached to hold it in place for the life of the measure.

### **3.18 Basements**

1. A basement shall be weatherized to be included as part of the conditioned space and thermal boundary if:
  - a. The heating system is designed to heat the basement, or
  - b. There are intentional heat registers for forced air systems or zonal heat present in the basement and operational, or
  - c. The residents are intentionally heating the space

If none of the conditions above exist then the space must be weatherized to separate it from the conditioned space and thermal envelope.

Conditions favoring underfloor insulation	Conditions favoring perimeter insulation
Zonal pressure shows floor more airtight than the foundation walls.	Zonal pressure shows foundation walls more airtight than the floor.
Damp underfloor with little or no improvement available through weatherization.	Ground cover and/or adequate perimeter drainage existing.
No heating system, ducts and plumbing located in the underfloor.	Heating system, ducts or plumbing located in the underfloor.
Exterior entrance and stairway only.	Interior stairway connecting the house and the basement.
Dirt floor or deteriorating concrete floor.	Concrete floor in reasonable condition.
Rubble or brick foundation walls.	Basement partially occupied or it contains the laundry room.



Rim joist insulation (foam board)



Rim joist insulation & ground cover

### 3.19 Unconditioned Basements

1. To effectively weatherize a basement to be separated from the conditioned space the following shall be evaluated:
  - a. Basement ceiling insulation R-value, airtightness and accessibility. Including stairway ceilings and walls.
  - b. Above grade wood framed wall insulation R-value, airtightness and accessibility. Including stairway walls. Closed wall cavities shall be insulated according to the procedures stated in the Wall Section starting on 2.06. Open wall cavities shall be insulated as in accordance with the section titled Open or Unfinished Wall insulation starting on 2.08.

- c. Door(s) separating the basement from conditioned space must be weather-stripped and substantially airtight. For details on weather-stripping doors, see section 6.
  - d. All ducts shall be air sealed and insulated in accordance to all specifications that apply to ducts. For details on sealing ductwork, see section 5.
  - e. Water pipes shall be insulated in accordance to all specifications that apply to water pipe insulation. See section 3.10 for specifics.
2. All penetrations through the floor shall be sealed in accordance with section 3.09. Basement ceiling insulation must be a minimum R-value of 25 or completely fill the depth of the cavity. Basement ceiling insulation shall be installed in accordance with all specifications that apply to underfloor insulation. (SWS 2.0401.1b)
  3. After installing basement ceiling insulation, a covering shall be installed on the bottom of the ceiling joist with a permeable air barrier (i.e. house wrap or equivalent) that meets Flame Guard R-3035 and has a flame spread of 200 or less. The cover shall be installed with seams overlapping at least 3”.
  4. The covering shall be twined as in accordance to insulation Support Systems, Section 3.14.
  5. If crawlspace insulation is installed over an unheated basement and the basement has no exposed soil (i.e. has concrete floors and walls), a ground cover is not required. Ventilation and relative humidity in the basement will be controlled to ensure condensation will not occur on cool surfaces. (SWS 2.0404.4c-e)

### **3.20 Conditioned Basements**

1. To effectively weatherize a basement to be included in the conditioned space the following must be evaluated:
  - a. Rim joist insulation R-value, airtightness and accessibility.
  - b. Above grade wood framed wall insulation R-value, airtightness and accessibility.

- c. Window and door U-value, airtightness and accessibility.
2. All exposed soil must be covered with ground cover as specified in section 3.15.
3. If rim joist insulation is installed it must be of minimum of R-15 and extend from the basement wall top plate/or sill plate, up the rim joist, and to the floor sheathing. All band/Rim joist areas will be open and accessible for application. Acceptable materials and procedures as follows:  
(SWS 4.1401.1a-b)
  - a. Insulation board cut to fit joist opening and air sealed around perimeter and any penetrations through the insulation board. Foam board must be faced. Facing must have a perm rating of 1 or less.
  - b. Closed cell spray polyurethane foam (SPF) with an accumulative perm rating of 1 or less. If the thickness of spray foam exceeds 3 inches, an approved thermal barrier is required (i.e. ½" sheetrock or approved coating). For installations of less than 3 inches, spray foam can be left exposed if rated as Class 1 and the rim joists are located in an uninhabited space. (SWS 4.1401.1c)

When polyurethane foam is used, the following must be ensured:

- 1) All surfaces where SPF is applied will be clean, dry, and free of contamination and degradation.
- 2) Substrate surfaces will be wiped, blown, or vacuumed to be free of excessive dust and dirt.
- 3) Grease and oil will be removed using appropriate cleaners or solvents.
- 4) Moisture content of all wood substrate materials must be checked to ensure it is below 20 percent. (SWS 4.1401.1a)

### **3.21 Partial Basements**

1. A partial basement is defined as a space below a home that contains both a basement and a crawlspace. The crawlspace may or may not have a wall to separate it or have crawlspace vents installed.
2. If the crawlspace is vented and a pony wall exists that separates the crawlspace from the basement then the floor above the crawlspace shall be weatherized in accordance with all sections pertaining to underfloor crawlspace. Special attention must be made to the pony wall to ensure that it

is an effective air barrier and if wood framed that it is insulated to minimum of R-21. See section 2.09 on pony walls. (SWS 3.1401.1b)

3. If there is no pony wall and no crawlspace ventilation then treat the area as one space. Answer the previous questions to determine if the space should be weatherized to be included with the conditioned space or excluded. If the basement is determined to be conditioned, then the crawlspace area must be separated from the conditioned area with a continuous air barrier.  
(SWS 3.1401.1b,d)
4. If the crawlspace is vented and there is no pony wall or the pony wall is in poor shape; either try to repair or build the pony wall as an airtight barrier between the crawlspace and basement or seal off the existing crawlspace vents and treat the crawlspace as part of the conditioned space. Note that if there is exposed soil that it must have ground moisture barrier installed as in accordance with section 3.15.

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## Section 4 : Water Pipe Insulation

- 4.01** Water pipe insulation should be installed to provide or facilitate freeze protection in unconditioned spaces. The insulation shall resist degradation from extreme moisture, light, and temperature.
- 4.02** Fiberglass strip insulation designed to be spirally wrapped around the pipe is not allowed.
- 4.03** The minimum insulation value after installation is R-3 for preformed pipe insulation or R-11 batt insulation.
- 4.04** When installing the water pipe insulation in connection with the water heater insulation wrap, the water pipe insulation shall not be installed in a position to interfere with or be within 6 inches from the gas water heater draft hood and/or single wall flue pipe or 3 inches if the flue pipe is made of B Vent. (SWS 7.8102.2i)
- 4.05** The first 6 feet of water heater inlet and outlet piping in unconditioned spaces must be insulated. (SWS 7.8103.1)
- 4.06** Tag all water pipe valves and/or controls that may be covered with insulation. Tags should hang below the final insulation for easy location.
- 4.07** Do not cover the operable part of pressure relief safety valves or devices.
- 4.08** The insulation shall be a material having a flame spread rating of 25 or less.
- 4.09** The water pipes shall be properly supported and free of leaks.
- 4.10** If using pre-formed water pipe insulation, cover the entire water pipe with properly sized pre-formed insulation. It should have a minimum lifetime of 10 years without degradation.
  - 1. Preferred installation of pre-formed pipe insulation is with the slits facing downward.
  - 2. Cut, fold, and/or mold the insulation to completely cover elbows, unions, T-connections, etc.
  - 3. Secure the insulation with twine, wire, plastic ties, adhesive, etc., without unnecessary compression.
- 4.11** Mobile homes floors: Water lines must be located on the warm side of the floor insulation; if not, the water lines must be insulated appropriately.

(SWS 4.1488.1b & 4.1302.1b)

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## Section 5 : Ducts

- 5.01 **General:** Material shall be installed according to the provisions of current Oregon Building Code or other applicable codes and shall meet the requirements of the agency weatherization program. Any exceptions shall be approved in writing in advance by the agency.
- 5.02 All exposed ductwork in unconditioned spaces must be inspected. Broken joints or large cracks, gaps, or holes must be identified. Type of ductwork (e.g., metal, duct board, flex duct) must be identified. Type and R-value of existing duct insulation must be identified as must the location of vapor retarders, if any. (SWS 3.1601.1a)
- 5.03 If asbestos tape/insulation was used, it must not be disturbed; consult with an asbestos abatement expert for removal or encapsulation. (SWS 3.1601.1a)
- 5.04 Screws or nails must be used to fasten boots to wood. (SWS 3.1601.1h)
- 5.05 A pre-manufactured or site manufactured durable filter slot cover must be installed if there is no existing cover. (SWS 3.1602.4d)



- 5.06 If any part of the duct system needs to be replaced, the replacement shall be a manufactured piece of like material preferably 30 gauge-galvanized metal. If existing ducts are too short to be joined together and secured with sheet metal screws, a manufactured duct section of proper size shall be installed and mechanically fastened by at least 3 equally spaced sheet metal screws at each joint in place before installing the mastic. (SWS 3.1601.1a, 3.1601.5b)



Damaged Flex Duct



Repaired With Rigid Insulated Duct



Before Mastic Sealing

### 5.07 Duct Sealing

All ducts must be sealed as airtight as possible before insulating ductwork. The agency may require removal of existing insulation in order to seal the ducts. Duct sealing must include, but is not limited to the following areas:

1. All joints and seams on the furnace plenums and furnace plenum connections. Plenum to air handler cabinet must be mechanically fastened. (SWS 3.1601.1f)
2. All joints and seams on return and supply ducts.
3. All boot connections to the interior floor surface and all elbow gores.
4. If a cold air return is located within a floor joist, then the sheet metal shall be sealed to the wood joist and it shall be sealed to the sub-floor. All possible joints, holes, cracks, seams, couplings, unions, connections, and furnace air handler cabinet shall be sealed.
5. Air leakage from the air handler shall be sealed as possible.

5.08 Sealing mastic shall be water-based (not solvent-based) material that will adhere easily to glass or mineral fiber, polyurethane or polystyrene foam, sheet metal, and cellular glass. 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. (SWS 4.1601.2b)

- 5.09 Mastic shall be applied in sufficient quantity to assure proper adhesion and coverage.
- 5.10 Surrounding insulation must be cleared to expose joints being sealed. Duct surface to accept sealant must be clean of all dirt and debris. (SWS 3.1601.1a)
- 5.11 If a gap is wider than 1/4 inch, before applying mastic to the areas to be sealed, the installer shall first install a 2 inch strip of fiberglass mesh tape. If this is not feasible in a given area, the installer may apply the mastic without the mesh tape being installed. Seams, cracks, joints, holes, and penetrations less than 1/4 inch must be sealed using fiberglass mesh and mastic. Mastic alone will be acceptable for holes less than 1/4 inch that are more than 10 foot from air handler. Seams, cracks, joints, holes, and penetrations between 1/4 inch and 3/4 inch will be sealed in two stages:
- They must be backed using temporary tape (e.g., foil tape) as a support prior to sealing.
  - They must be sealed using fiberglass mesh and mastic. (SWS 3.1602.1b)
- 5.12 Seams, cracks, joints, holes, and penetrations larger than 3/4 inch must be repaired using rigid duct material. Fiberglass mesh and mastic must overlap repair joint by at least 1 inch on all sides. (SWS 3.1602.1c).



Mastic Being Applied Over Mesh Tape



Before



After

#### **5.14 Duct Insulation:**

The entire system located in unconditioned spaces, including plenums, cold air returns and boots shall be insulated if cost effective. Lined ducts and lined plenums shall be insulated. Ducts and plenums shall be insulated with a minimum R-11 fiberglass batt or blanket with a compressed, installed R-value of at least R-9. If the ducts are located in an attic area, a minimum of R-19 fiberglass batts or blankets shall be installed. All duct insulation must have an attached vapor retarder. There shall be no gaps between pieces of duct insulation. (SWS 4.1601.2a & d)

- 5.15 Ducts subject to routine human contact, (i.e. garage, basements and attics used for storage) shall be sealed, insulated, and covered with a material that has suitable facing cover that provides physical protection and has a flame-spread rating of 25 or less.
- 5.16 Using a tape approved by the manufacturer, all seams and connections of the duct insulation in areas of routine human contact must be taped so that no metal or insulation is exposed. (Variance SWS 4.1601.2d, 4.1601.5d)
- 5.17 The surface of any pan joist cavity used as a duct in an unheated area shall be insulated to recommended levels or as specified on work order.
- 5.18 Duct insulation must be secured to the duct system using corrosion resistant metal wire or rot-proof nylon twine. Twining shall be installed in a circular fashion and spaced no greater than 18 inches or in the case of rectangular ducts, twined and stapled to the floor structure. (SWS 4.1601.2c)

#### **5.19 Flexible Duct:**

Installation of flexible ducts is discouraged. However if conditions require the installation of flexible ductwork, documentation must be included in the file. Install Flex Ducting as follows:

1. All flexible ducting installed must have a minimum of R-8. All accessible low R-value flexible ducting must be removed from premises. Duct sizing procedures must be conducted when replacing flex duct.
2. Interior liner of the flex-to-metal connection must be fastened with tie bands using a tie band tensioning tool or a mechanical band.
3. Exterior liner must be pulled up onto the metal duct as far as possible before securing. The exterior liner must be fastened with tie bands using a tie band tensioning tool.
4. All accessible joints, seams, and connections in ductwork must be securely fastened and sealed with UL "181 B-M" compliant mastic (adhesives) or mastic-plus-embedded-fabric systems.
5. Vapor barrier of all duct insulation must be taped to the flex duct using the taping system required by the manufacturer of the flex duct.

6. All metal fittings including boots, elbows, and take-offs must be insulated separately using an R-11 duct wrap with vapor retarder. Vapor retarder of all duct insulation must be taped to the flex duct using tape that complies with UL 181B.
7. Crawlspace must be sufficiently sealed to ensure the ductwork is properly protected from animals. (SWS3.1601.1c, 4.1601.1a-j; 4.1601.4a-j)

## 5.20 Supporting Ductwork:

Ducts located in crawlspaces shall be supported off the ground and secured to the floor structure with corrosion resistant wire or galvanized metal hangers. When ducts are in contact with ground extruded rigid polystyrene foam (such as Dow Styrofoam™ “blue board”) shall be used between the duct and the ground. Flexible and duct board ducts and plenums must be supported every 4 foot using a minimum of 1 1/2 inch wide material. Support materials must 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 must 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. (SWS 3.1601.3a)



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## Section 6 : Air Sealing in Site Built Homes

- 6.01 **General:** Material shall be installed according to the provisions of current Oregon Building Code or other applicable codes and shall meet the requirements of the agency weatherization program. Any exceptions shall be approved in writing in advance by the agency. Presence of lead-based paint in pre-1978 homes must be assumed and when paint is disturbed, appropriate precautions taken unless testing confirms otherwise. (SWS 3.1202.1a -3.1201.8a)
- 6.02 Air sealing shall be addressed on all residences accepted for low-income weatherization.
1. The forced air heating and cooling distribution (duct) system may be required to be sealed, including plenums, boots and registers. All accessible forced air heating or cooling ducts shall be sealed. Supply ducts are a top priority for sealing.
  2. All broken glass or missing panes in prime windows shall be replaced unless cracked glass is not noticeably separated or a hazard. See section 7 for specifics on installation.
  3. All large, obvious leaks in the building envelope shall be sealed.
  4. All interstitial spaces (house/garage connection, attic/floor penetrations etc.) must be sealed.
- 6.03 Caulking for air sealing purposes shall only be performed on the inside surfaces of the structure except when otherwise stated on the work order. Installers shall follow the manufacturer's instructions for application of caulk.
1. All dirt, loose or peeling paint, caulking and other debris shall be removed from the surface where caulking is to be applied.
  2. The depth of caulk shall not be greater than the width of the joint.
  3. Filler materials, such as polyurethane foam, backer rod or other suitable materials shall adequately support the caulk when cracks are deeper than 1/2".
  4. Single-component polyurethane foam sealants may be used as filler material or as a caulking material provided the manufacturer's installation standards are met.

5. Exterior caulking used as sealant for window glazing replacements shall be one component polyurethane or polysulfide meeting the standards of TT-S-230c.

#### 6.04 House - Garage Connection

1. All lighting fixtures, wiring, plumbing, venting, ducting and gas pipe penetrations must be sealed using appropriate materials. (SWS 3.1501.1a)
2. All joints and connections in ductwork located in the garage must be sealed and fastened using UL 181B rated materials. (SWS 3.1501.1b)
3. All holes in the air handler cabinet shall be sealed. (SWS 3.1602.4c)
4. Open filter slots must have a cover installed. A durable pre-manufactured or site fabricated filter slot cover must be installed. (SWS 3.1602.4d)



Foil tape should be used to seal all holes in air handler cabinets



Open filter slots must have new covers installed



A properly fitting filter slot cover prevents garage pollutants from entering the conditioned space

5. All cracks or gaps in surfaces that separate the house/garage must be sealed. (SWS 3.1501.1c).
6. Door weather-stripping shall be installed on all 4 sides of any door connecting the conditioned space and the garage if existing weather-stripping is not effective. See section 6.12 - 6.20 for details. (SWS 3.1501.1d)
7. Any broken glass must be replaced unless cracks are not noticeably separated or a hazard. (SWS 3.1501.e)



Inspect garage/house wall for cracks and penetrations



Apply appropriate sealant dependent upon size of the crack and location



Ensure sealant completely fills gaps. After curing, remove excess sealant

6.05 Bypasses shall be defined as any gap in the envelope of a house between a conditioned and unconditioned space. Bypass locations include, but are not limited to the following areas: chimneys (masonry and metal); soil stacks and plumbing vents; open plumbing walls, top plates of interior partition walls and exterior walls; housing of exhaust fans and recessed lighting fixtures; dropped ceilings; beneath knee walls; around duct work; electrical penetrations; clothes chutes and dumb waiters; party walls and attic access points. See Appendix C for details and techniques for sealing bypasses.

6.06 Interior plumbing penetrations shall be sealed.

1. Backing material must be provided on larger penetrations. The backing material must not sag after installation. Backing material used must be compatible with sealant. (SWS 3.1101.2b)
2. Sealants used must be compatible with the surface on which they are installed.
3. For larger repairs under sinks, any rigid material may be used as long as it meets flame spread requirements and is durable enough to last for the life of the structure.

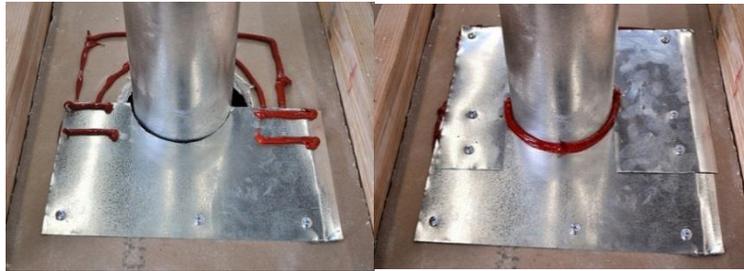
6.07 Chimney/fireplace masonry chimneys with flues used for wood burning, natural gas or for oil burning purposes shall have the bypasses sealed with a draft stop of sheet metal sealed to the chimney or flue and ceiling structure with a high temperature caulk. (SWS 3.41201.1c)



Prepare the work area by removing insulation

Apply caulking around the opening

Apply a second layer of sealant



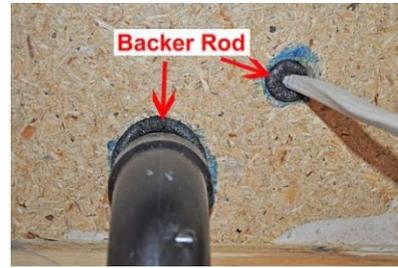
Shape rigid material to fit flue. Fasten rigid material and apply additional caulking

Fasten rigid material to cover the penetration and seal around flue with high temperature caulking

- 6.08 Sealing of all penetrations through the floor shall be included in all floor insulation work. Particular attention is necessary under bathtubs, shower stalls, heating registers, and where plumbing or electric devices penetrate the floor.
1. Backing material must be provided on larger penetrations. The backing material must not sag after installation. (SWS 3.1402.1a)
  2. Sealants used must be compatible with the intended surfaces and must allow for expansion of dissimilar materials. (SWS 3.1402.1b)
  3. All combustion flue penetrations shall be sealed using appropriate non-combustible material. (SWS 3.1402.1c)
  4. Combustion air supplies in unconditioned spaces must be labeled for identification and must **not** be blocked or sealed. (SWS 3.1301.1d)



Prepare work space by removing any insulation



Install backer rod if necessary



Apply appropriate caulking to ensure backing does not move.



Visually inspect to verify no gaps remain

6.10 Walls between conditioned and unconditioned spaces shall have all penetrations sealed.

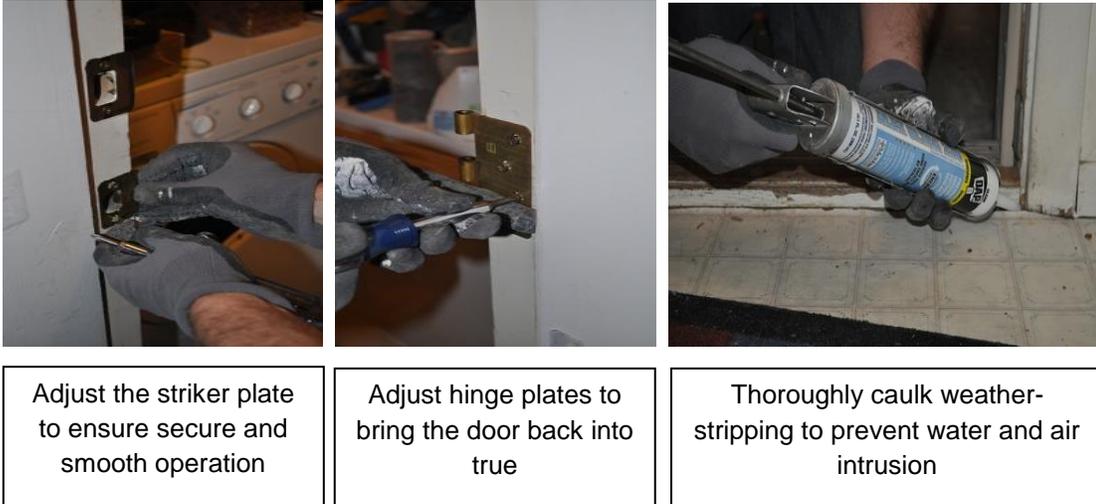
1. All holes and penetrations on the interior surface of exterior walls must be repaired. Like material and/or compatible materials must be used for repairs. (SWS 3.1101.2c)
2. When sheetrock repairs are needed, a minimum of one coat of tape and one coat of mud are required.
3. Backing or infill must be provided as needed to meet the specific characteristics of the selected sealant and the characteristics of the penetration. (SWS 3.1101.2b)

6.11 Door weather-stripping shall be one of the following types:

1. Low temperature vinyl or silicone with rigid flange.
2. Interlocking metal.
3. Neoprene.

Note: Self attaching weather-stripping (self-stick or glue type) is prohibited for door weather-stripping unless the door is designed to use such weather-stripping (e.g. metal manufactured home outswing doors).

- 6.12 Weather-stripping material shall be installed in accordance with the manufacturer's instructions.
- 6.13 Doors and windows weatherstripped must be adjusted to properly fit the jamb and allow for ease of operation. (SWS 3.1201.3b)



- 6.14 If water intrusion is an issue, steps must be taken to stop water intrusion (e.g. adjust threshold, caulking or flashing). (SWS 3.1201.3d)
- 6.15 Surface-mounted weather-stripping material shall be installed to ensure that the weather-stripping sufficiently contacts both surfaces and that the gap is adequately sealed.
- 6.16 Weather-stripping shall be installed in one continuous strip, if possible, along each side of the door or window. The material shall fit tightly at the corners to maintain continuity around the perimeter of the door or window.
- 6.17 All mounting screws, nails, staples or other fastener devices shall be of a non-corrosive material compatible with the weather-stripping material installed.
- 6.18 Weather-stripping material shall be secured with mounting screws, nails, or staples spaced a maximum of 4 inches apart, unless metal or metal-backed weather-stripping is used and supplied with pre-drilled holes. Door weather-stripping shall be secured at the bottom of each side of the weather-strip; the fastener shall be located no higher than 2 inches from the threshold. In no case shall fasteners be over 12 inches apart.
- 6.19 Door bottom weather-stripping may be threshold, interlock or door-bottom mounted vinyl bulb (door shoe). Door bottoms shall not have a surface sweep that rubs against the floor. A fixed door sweep is a door sweep that is permanently attached to the bottom of a door. For the definition of a door sweep see Appendix Z.

- 6.20 Upon completion of the job, all windows and doors that have had weather-stripping installed shall operate properly without undue force and provide a complete air infiltration resistant seal in the most restrictive position. Both door lock and deadbolt lock set shall work without undue force caused by the weather-stripping. The occupants must be notified of changes or repairs made and educated on how to maintain weather-stripping. (SWS 3.1201.3e)

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## Section 7 : Windows and Doors

- 7.01 **General:** Material shall be installed according to the provision of current Oregon Building Code or other applicable codes and shall meet the requirements of the agency weatherization program. Replacement windows must be installed in accordance with manufacturer specifications. Any exceptions shall be approved in writing in advance by the agency. (SWS 3.1203.1c)

Presence of lead-based paint in pre-1978 homes must be assumed unless testing confirms otherwise. (SWS 3.1203.1a)

Windows contribute to the total heat loss in most homes in three ways:

1. Conduction of heat through windows and their frames.
2. Air infiltration through the cracks around the windows.
3. Radiation through the glass.



In some cases where the existing prime windows are in poor condition, replacing the existing sashes or the entire window and casing with a double pane unit may be the best approach.

- 7.02 Glazing for windows is restricted to glass. Permission may be given by agency to use plastic glazing in special circumstances.

### 7.03 Safety Requirements

1. Safety glazing shall be used when appropriate. The installer of the glazing is responsible for utilizing safety glass as necessary. See the section on Safety Glass requirements, Section 7.21- 7.29 for details.  
(SWS 3.1202.3e, 3.1203.2e & 3.1202.1d)

2. Egress requirements: If a new window is installed in a sleeping room or basement with habitable space and the existing opening size is altered, then the appropriate egress requirements must be met. If the existing opening size is not altered, egress requirements do not have to be met. Existing egress windows must only be replaced with windows that meet egress requirements. All egress windows and doors must be operable as required by local codes. (SWS 3.1203.1d, 3.1201.5c & 3.1203.3f)
- 7.04 Any exposed wood, either existing or added, shall be finished with a sealer to prevent future warping, swelling or rotting. Acceptable alternatives are to use naturally decay-resistant wood such as cedar or to use chemically treated wood. Prior approval by client is necessary.
- 7.05 Hardware shall be durable, function properly and not create interference. Hardware and fasteners shall be aluminum, stainless steel, or other non-corrosive materials chemically and visually compatible with the window frame. Cadmium or zinc-plated steel, where used with aluminum windows shall meet the requirements of ASTM B-633-78 or A-1 6580.
- 7.06 Windows shall have no burrs, splinters or other potentially hazardous conditions that could cause harm to the occupant.
- 7.07 After installation, windows and patio doors shall operate smoothly and properly. When closed, the entire assembly shall provide a complete weather barrier for the entire opening.
- 7.08 Any vinyl or metal shavings or other debris shall be cleaned up.
- 7.09 Screens shall be furnished with all operable window systems; however, exceptions are allowed. For outward opening window types where there are no existing screens or where the existing screens remain fully functional. In addition, screens for other window types need not be supplied where existing screens remain fully functional or where the prime windows were never designed to have screens.
- 7.10 Glazing Replacement**

Replace missing or broken glass or glass that is cracked and noticeably separated that affects the structural integrity of the window. Ignore glass cracks that are not noticeably separated or a hazard. Tempered or Safety glass must be used as necessary. (SWS 3.1202.1d & 3.1202.3e)

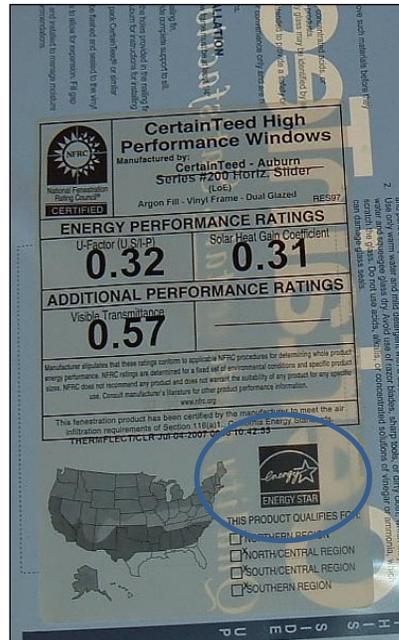
1. Windows that use glazing compound:
  - a. Glass and putty shall be removed, surfaces shall be cleaned.
  - b. Wood frames: A coat of linseed oil should be installed prior to installing replacement glass.
  - c. Glass must be sized 1/8 inch to 3/16 inches smaller than opening to allow for movement of frame.
  - d. Glass should be set into a bed of glazing compound, secured with glazing points (2 inches from each corner and not less than 8 inches apart) and puttied with latex or oil based glazing compound. Glass set in metal frames should have metal-glazing clips no more than 12 inches apart and within 4 inches of each corner and the joint between the two surfaces puttied. Glazing shall be neat in appearance and installed with a slope to ensure water runoff. (SWS 3.1202.1b, c, d)
2. Other types of windows:
  - a. Broken glass shall be removed.
  - b. Opening must be cleaned and original sealant must be removed.
  - c. Replacement glass must be sized to original size.
  - d. Glass must be sealed and installed in accordance with the original installation design. (SWS 3.1202.3 c, d, e )

### **7.11 Replacement Windows and Patio Doors**

Windows and Patio doors installed under the program shall be Energy Star™ rated or equivalent for use in Oregon. Windows funded under utility programs may have additional requirements. (SWS 3.1203.4a - 3.1203.3c)

1. Replacement glazing shall also incorporate Sealed Insulated Glass Manufacture's Association (SIGMA)-approved Class sealed-glass units. The manufacturer shall mark and certify units in one of the of the following three ways:
  - a. By a stamp on the spacer bar or;
  - b. By an etching on the glass itself or;
  - c. By a label between the panes of glass.

2. The identification shall include the agency, which certified the unit (e.g. the Associated Laboratories, Inc. ALI or National Fenestration Rating Council- NFRC), the class or classes that the unit meets, and the date manufactured.



Energy Star Label

**7.12 Replacement Window Preparation:** Before installing a replacement window in to an existing window frame, Interior stops, sashes, parting strips, and pulleys shall be removed.  
(SWS 3.1203.1b)

1. Prior to installing replacement windows:
  - a. The window opening shall be cleaned.
  - b. Any damaged framing shall be replaced.
  - c. The opening shall be prepared according to manufacturers' instructions.  
(SWS 3.1203.3d & 3.1203.1b)

**7.13 Installing Replacement Window into a single family home:**

1. Exterior trim shall be removed or exterior siding must be cut back to fit new window with trim.

2. Windows shall be installed in accordance with manufacturer specifications and shall be integrated with flashing installed in accordance with accepted industry standards. (SWS 3.1203.2d & SWS 3.1203.2b)

			
Install flashing to manufacturers' specs and industry standards	Install window in opening	Secure flange to manufacturers specs	Once secured, verify window operates properly

		
Verify window hardware works properly	Foam or caulk gaps around the frame.	Replace exterior trim and patch siding as needed

#### 7.14 Installing windows into a manufactured home:

1. Windows installed shall be approved by the manufacturer for manufactured home use.
2. Butyl Tape shall be installed behind the mounting flange.
3. Windows with nailing fin shall be secured with corrosion resistant screws. All manufactured holes in the nailing fin shall be used. (SWS 3.1203.3d & 3.1203.1b). Flush (stucco) fin windows shall be secured to manufacturers' requirements. Excess butyl tape shall be removed after securing windows. Both the interior and exterior of the installed window shall be sealed. (SWS 3.1203.3c)

**7.15** Sealing Requirements: Cracks between the window frame or patio doorframe and the frame of the rough opening shall be caulked or foamed with low expanding foam.

1. Caulk shall be applied to a smooth, clean, dry surface.
2. Sealants must always be applied in a continuous bead and free of voids, with a smooth and neat appearance.
3. When using caulking, openings 3/8 inch to 7/8 inches wide should be filled to within 1/2 inch of the surface with an appropriate packing material specifically manufactured as a packing material prior to caulking. All packing material must be compatible with the type of caulk used.  
(SWS 3.1203.2d & 3.1203.1c)

**7.16** Sealants

1. Sealants must be compatible with their intended surfaces and applied in accordance with manufacturer specifications.
2. Sealants must be durable, pest resistant, and have a weather-appropriate seal.
3. Sealants used on interior surfaces must be low VOC products.
4. Exposed sealants shall be paintable.
5. Sealants shall meet Federal Material Specification and Standards listed in Appendix X. (SWS 3.1203.4e)

**7.17** Multi-glazing in Existing Frame: Multi-glazing shall not be installed where sash material has deteriorated or does not possess adequate strength, support, or anchorage for the multiple panes. Structural repairs or replacements shall be accomplished prior to weatherization.

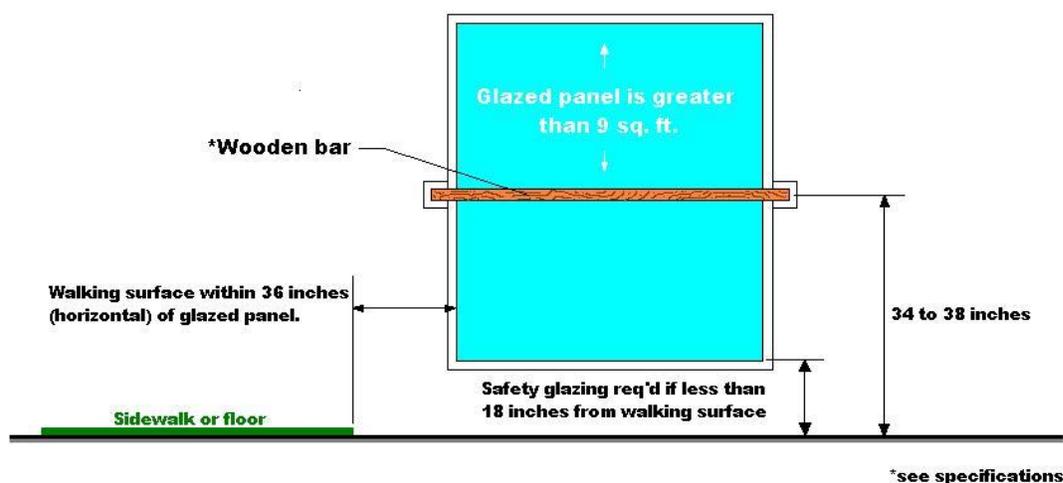
1. Any worn or damaged rollers shall be replaced with metal rollers. Deteriorated track systems shall be replaced or repaired with track covers.
2. Worn or damaged weather-stripping shall be replaced unless noted otherwise on the audit. This includes replacement of the meeting rail weather-stripping.
3. All materials used shall be compatible to the manufacturer's slide system and be a permanent repair or replacement.

**7.18** Multi-glazing should replace existing single-pane glazing in entrance doors located between conditioned and unconditioned space when repairing doors.

1. Edges of multi-glazed units shall have no edge damage no hairline cracks at the periphery and no holes in the edge sealants. Materials damaged in shipment or installation shall not be used.
2. Glazing compounds and gaskets shall be installed with a slope to ensure water runoff. Such compounds shall not contact the seal of the multi-glazed unit or the material shall be shown to be chemically compatible with the seal of the multi-glazed unit.
3. Follow requirements for determining if safety glass is required. See Section 7.21- 7.29.

**7.19** Spacer blocks shall be installed according to the manufacturer's installation recommendations.

## Safety Glazing Requirements



### **7.20 Safety glazing requirements**

In addition to other requirements all safety glass shall conform to the Safety Glazing Certification Council (SGCC) labeling requirements.

1. Certified and permanently labeled laminated glass may be cut into smaller pieces after being manufactured.

2. If it is not practical for each smaller piece to bear a manufacturer's permanent label, the window manufacturer shall apply a permanent label etched to each smaller piece.
3. The etching shall identify the window manufacturer and certify that the material as cut from properly labeled safety glazing.

**7.21** When measuring glazing, measure only the area of glass (sash is not to be included).

**7.22** Sidelights – A sidelight is the pane of glass next to a door. Safety glass is required if all three of the following conditions exist:

1. The glazed panel is within 12 inches of the door opening and
2. The glazed panel is within 60 vertical inches of the floor and
3. The window is in the same plane as the door when the door is closed.

**7.23** Safety Glass is required in fixed or operable panels adjacent to a door where the nearest exposed edge of the glazing is within a 24 inch arc of the vertical edge of the door in a closed position and where the bottom edge of the glass is less than 60 inches above the floor or walking surface unless there is an intervening wall or permanent barrier between the door and the glass.

**7.24** Other Glazed Panels - Safety glass shall be installed where panes of glass, other than sidelights, are located in hazardous areas. This standard applies when these three conditions exist:

1. Glazed panel is greater than 9 square feet when measured from the inside of the sashes.
2. The lowest edge of a glazed panel is less than 18 inches above a walking surface and
3. There is a walking surface, for example, a sidewalk or floor within 36 horizontal inches of a glazed panel.

An alternative to using safety glazing if these requirements are met is to put a wooden bar across the window opening. It shall be at least 1 1/2 inches wide. It shall be attached between 24 inches and 36 inches above the walking surface and be on the same side as the walking surface. If there is a walking surface on both sides of the window, then bars need to be used on both sides of the window. The bars shall have the deflection strength of a 2 inch by 2 inch #1 lumber. Bars shall not be used on sidelights.

- 7.25** All storm doors, sliding glass doors, and prime doors with glass panes shall use safety glass if a 3 inch or larger sphere can pass through the glazing opening.
- 7.26** Windows within bathtub and shower enclosures shall be of safety glass unless the bottom of the glazing is 60 inches or greater vertically from the bathtub drain.
- 7.27** Plastic glazing shall not be used in place of safety glass.
- 7.28** Fixed panels of glass contained in one window surrounded but separated by structural mullions, do not need to be safety glass if they are not located in a hazardous area.

**7.29 New Exterior Doors**

1. Replacement slab doors shall be solid core, weatherstripped, caulked and be sealed on all edges in accordance with manufacturer's printed instructions.
2. Replacement insulated entrance door units shall have a minimum thermal rating of R-7. Caulking or foam shall be applied between the jamb of the door and the rough opening.
3. New doors shall operate freely and not bind; no gaps or openings shall exist around the perimeter. (SWS 3.1201.3b)
4. The door unit shall have a lockset. The unit shall operate properly to meet egress requirements.
5. Weather-stripping shall meet specifications in Section 6.

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## Section 8 : Dwelling Performance Assessment

### 8.01 General

Weatherizing homes with combustion appliances, moisture problems, and pressure imbalances has created the need for increased testing, and in some situations, corrections. The following is a list of testing and possible correction procedures.

### 8.02 Blower Door Testing

One hundred percent of the homes require pre and post blower door tests. Documentation of the results of these tests shall be included in the occupant or homeowner file. In the event that either test cannot be performed, documentation is required. (See Appendix B sample test form).

1. One hundred percent of housing with four or less units requires pre and post blower door tests if conditions allow. Documentation of the test results shall be included in the job file. In the event that either test cannot be performed, documentation is required.
2. Performing pre and post blower door testing on every unit in low rise ( $\leq 3$  stories) garden style buildings having 5 or more units would be best practices, but that is not always practical. Testing a representative sample of the units is acceptable, consisting at a minimum of testing of 20 percent each different type unit based on floor level, volume, inside or outside unit, etc. Utilize the following sampling procedure to determine the level of testing necessary:
  - a. Perform “initial sample” blower door shell testing on 10 percent of the units with each floor plan or three units, whichever is greater.
  - b. Average the sample blower door tests and add 15 percent. This is your acceptable maximum CFM50 shell leakage (AMSL).
  - c. Perform a blower door on an additional 10 percent with each floor plan or three units, whichever is greater.
  - d. If the leakage rate in the additional 10 percent sampling is within the AMSL, the 20 percent sampling is sufficient.
  - e. If the leakage rate exceeds the AMSL on any of the additional units, a minimum of 30 percent of each floor plan must be tested.
  - f. Documentation of each testing sample is required.
3. In the event of a low rise ( $\leq 3$  stories) garden style apartment complex with many buildings of similar design consisting of 4 or less units. The above testing protocol is acceptable. Documentation of the testing process is required.

4. High Rise Apartments - The Weatherization Assistance Program (WAP) does not require high-rise residential buildings to be blower door tested. Prescriptive air sealing is required in high-rise buildings in lieu of blower door testing.



### 8.03 Duct Pressure Testing

Pre and post measurements of duct leakage are required on all homes with forced air systems. Test results shall be recorded on the test data form and included in the job file. (SWS 3.1602.9h, 3.1602.8f)

1. Duct blaster test: Follow set-up directions & specifications for duct leakage (Appendix T).
  - a. All ducts must be sealed as airtight as possible before insulating ductwork or installing insulation in a mobile home floor. The goal is to seal ductwork as airtight as possible.
  - b. Duct sealing must include, but is not limited to the following areas:
    - 1) Joints on the furnace plenum and the furnace plenum connection.
    - 2) Joints and seams on cold air return and supply ducts.
    - 3) Where the boots connect to the interior floor surface and elbow gores.
    - 4) Air leakage in the air handler should be sealed as possible.
    - 5) Metal sweeps or rigid insulation board blocks must be installed and sealed where duct runs extend beyond the last register.

- c. Based on the protocol for testing “Duct Leakage to the Outside” (appendix T), duct leakage at 50 pascals in a retrofitted system must:
- 1) Be reduced to 10 percent of the floor area or less after sealing; or
  - 2) If the duct leakage at CFM 50 cannot be attained after all joints and seams are sealed, then a 50 percent reduction from pre-test levels is acceptable. There must be documentation in the file explaining why the 10 percent standard was not achievable.



Pressure pan may be used for troubleshooting leakage in specific ducts only. Refer to Appendix S.

## 8.04 Combustion Appliance Inspection and Testing

1. General: 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

(SWS 2.0201.1a)

Ambient CO will be monitored during combustion testing and testing will be discontinued if ambient CO level inside of home or work space exceeds 35 ppm. Raw fuel leaks will be monitored before entering buildings spaces and reported to occupant immediately if found.

(SWS 2.0103.1b-c, 2.0103.2f)

Unvented combustion space heaters of any type must be removed from the home with the occupants' permission before weatherization can be completed. If the occupant will not allow removal of the equipment, the project must be deferred. Occupants must be educated on the potential hazards of unvented combustion appliances. (SWS 2.0401.1c, 2.0202.1a-b)

2. Data Plate Verification: Information for both existing and new equipment must be recorded from indoor and outdoor equipment data plate(s) and recorded in the file.  
(SWS 5.3003.1a)
3. To ensure combustion problems are identified and the combustion appliances are operating properly at the end of the weatherization process, worst case depressurization (WCD), CO, spillage and draft testing are required to be performed and documented both pre and post weatherization.
4. To ensure the safety of clients during the weatherization process, a functioning CO alarm must be present in the home. If not existing, a new CO alarm must be installed in accordance with ASHRAE 62.2 and manufacturer specifications before any work is completed in all homes. Occupants shall be educated in the operation and maintenance of the CO alarm as well as provided information on the health effects of CO.  
(SWS 2.0301.2a-b, 2.0201.2c, 2.0203.4a-b, 2.0203.6d-e, 2.0301.2a-b)
5. Gas leak testing must be completed on all gas appliances. Any leaks found must be clearly communicated to the client and appropriate repairs completed. (SWS 2.0201.1a, 2.0103.2e-g, 5.3003.2a)



Inspect exterior fuel lines for leaks or damage.



Use soapy water or a gas leak detector to locate leaks.



Inspect flex lines for damage, Replace if flex line is dated before 1973.

## 6. Vent System Inspection

The vent system of all combustion appliances must be inspected and any problems mitigated if necessary. Combustion venting systems must be

- inspected for damage, leaks, disconnections, and other safety hazards, including but not limited to:
- a. The presence of an operable draft regulator on natural draft appliances.
  - b. A minimum slope of ¼ inch per foot slope on venting.
  - c. Properly sized vent for the appliances it is serving. Pay special attention to orphaned water heaters to ensure the vent is not oversized. Vent size shall be determined using the NFPA 54 venting tables.
  - d. Verify the proper vent type was used for the type of appliance.
  - e. If any vent system hazards are identified, repairs must be completed to mitigate the issues before any shell measures may be completed. (SWS 2.0203.2b, ,)
7. Baseline pressure must be measured in Combustion Appliance Zone (CAZ) with reference to outdoors. (SWS 2.0201.1d)
  8. If combustion appliances including woodstoves or fireplaces are present, a worst-case depressurization (WCD) test is required both pre and post weatherization. Depressurization test must include exhaust fans, interior door closure, or duct leakage, or a combination thereof and must account for base pressure. Worst case depressurization combustion appliance zone (CAZ) with reference to (WRT) outside shall not exceed the House Depressurization Limit (HDL) found in Appendix M. Test results shall be recorded on the test data form and included in the occupant or homeowner file. (SWS 2.0201.1e)
  9. If natural draft combustion appliances are present in the conditioned space and envelope and/or duct sealing is completed, a worst case depressurization test and spillage test must be performed and documented at the end of each work day when any of the following conditions apply:
    - a. A dominant duct leakage test performed during the audit shows the home to be positively pressured WRT outside and correcting the pressure imbalance may compromise the proper operation of the appliance or;
    - b. At the initial audit, the draft is below minimum draft pressures in WCD listed in Appendix K and not corrected before weatherization work is initiated or;

- c. At the initial audit, the WCD test exceeds the HDL listed for the appliance type in Appendix M and not corrected before weatherization work is initiated or;
  - d. Major infiltration work is being performed that may have a negative impact on the draft of the appliance(s) or;
  - e. Any other condition that the auditor identifies that may compromise proper operation of the appliance(s). (Variance-SWS 2.0201.1i)
10. Spillage testing: Spillage occurs commonly on initial fire up of atmospheric appliances. Spillage beyond the limitations of this specification is called back drafting. Back drafting is a hazardous condition and unacceptable. A Spillage test measures the amount of time it takes for appliance to establish a draft with all exhaust fans on and the house set up in worst case. Testing shall be performed for back drafting or spillage of combustion gases of more than 2 minutes. If spillage exceeds 2 minutes with a warm vent or 5 minutes with a cold vent, mitigation repairs are required. Test shall be done using chemical smoke or mirror and shall be done on all sides of the draft hood. Test results shall be recorded on the test data form and included in the occupant or homeowner file. Refer to Appendix N.  
(SWS 2.0203.2a-c, c, , 2.0203.1c, , 2.203.6c)



On water heaters, test for spillage on all sides of the draft diverter



On natural draft furnaces, test for spillage on all sides of the draft



Test for spillage using chemical smoke or a mirror.

11. Draft flue pressures shall meet the minimum acceptable draft pressures as listed in Appendix K. Draft testing should be performed in the following areas:
- a. For oil furnaces, draft should be measured in the breech section of the flue pipe before the barometric damper.

- b. For atmospheric draft and induced draft furnaces, measure draft in flue pipe.
  - c. For atmospheric draft water heaters, measure draft in the flue pipe.
  - d. For sealed combustion or power vented appliances, no draft testing is required.
12. Ambient carbon monoxide (CO) test shall be performed 5 minutes after appliance startup. All homes with natural gas, oil, propane, or wood fueled appliances are required to be tested for carbon monoxide levels both pre-weatherization and post-weatherization. Test results shall be recorded on the test data form and included in the occupant or homeowner file. Maximum allowable ambient CO concentration level is 9 Parts per Million (ppm). Refer to Appendix O. Continue to monitor ambient CO levels during combustion testing. If ambient CO levels exceed 35 ppm, testing must be discontinued and appropriate repairs made before proceeding. (SWS 2.0103.1b, 2.105.1b)
13. Combustion appliance CO level tests the CO level of each combustion appliance at the location described below by letting them run for approximately five minutes, allowing them to reach steady-state efficiency before taking a reading. Installer test results are to be included on the test data form provided at the time the project work order is issued.
- a. Gas Range
    - Oven
    - 1) Maximum CO concentration levels for a gas oven are 225 ppm as measured.
    - 2) CO must be measured inside the oven exhaust port.
    - 3) Ensure any items in the oven are removed before testing.
    - 4) Remove any foil lining the oven if present and advise client of the hazards of lining the oven in this manner. (SWS 2.0201.2d)



Test for CO in the oven exhaust port

### Range Top Burners

- 1) Light all range top burners and observe flame patterns. Specify a clean and tune if the flame has any discoloration, flame impingement, or an irregular pattern or if burners are visibly dirty, corroded, or bent. (SWS 2.0201.2e)



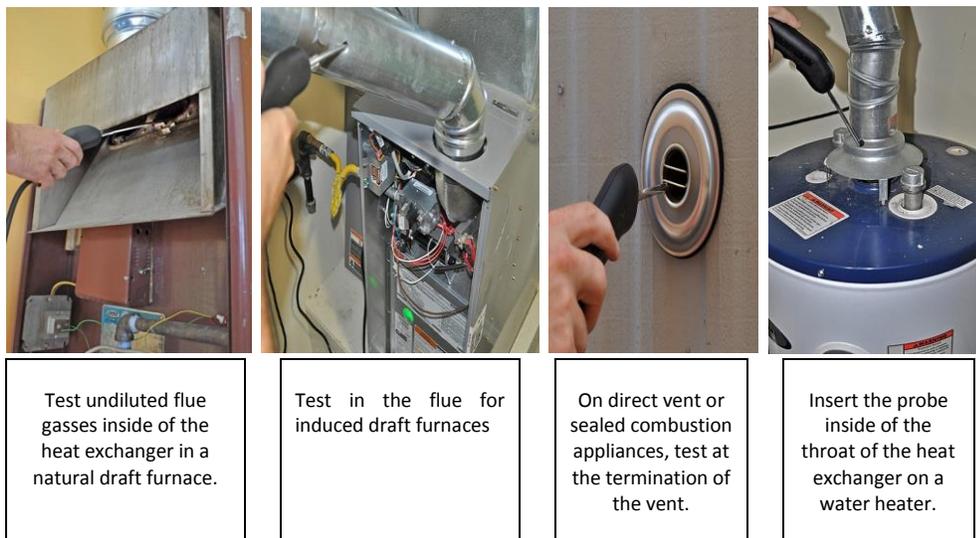
Uneven luminous flames are a sign that the burners require servicing.



Uniform blue flames indicate a properly operating burner.

- b. Combustion appliances other than gas ovens: Maximum allowable CO concentration 400 ppm air-free for furnaces and 200 ppm air-free for water heaters or room heaters. Service will be provided to reduce CO to below these levels (unless CO measurement is within manufacturer specifications). Testing locations are listed below: (SWS 2.0201.3b)
  - 1) For oil furnaces, CO should be measured in the breech section of the flue pipe before the barometric damper.
  - 2) For atmospheric draft gas furnaces, measure CO before the draft diverter.

- 3) For induced draft gas furnaces, measure CO in flue pipe.
- 4) For sealed combustion gas furnaces, measure CO at termination.
- 5) For gas water heaters, measure CO at top of water heater before draft diverter hood, as possible.



Test undiluted flue gasses inside of the heat exchanger in a natural draft furnace.

Test in the flue for induced draft furnaces

On direct vent or sealed combustion appliances, test at the termination of the vent.

Insert the probe inside of the throat of the heat exchanger on a water heater.

14. Combustion air (CA) enters the combustion appliance zone (CAZ) through intentional or unintentional openings in the building shell or through a dedicated pipe from outdoors. Use pre and post weatherization worst case depressurization, worst case draft and combustion testing to determine whether or not to add additional combustion air to existing combustion appliances. Additional CA should only be added when testing indicates that additional CA is needed. In the event that testing proves additional CA is necessary, it must be installed to the following guidelines: (SWS 2.0203.1a-b, 2.0203.2a, , 2.0203.2c-d)

a. Location	b. Dimensions
Two direct openings to an adjacent space.	Minimum area each: 100 sq. inches 1 sq. inch per 1000 BTUH input each opening Combined room volume must be $\geq$ 50 cubic feet/ 1000 BTUH input
Two direct openings or vertical ducts to outdoors.	Each vent should have 1 sq. inch for each 4000 BTUH input

Two horizontal ducts to outdoors.	Each vent should have 1 sq. inch for each 2000 BTUH input
Single direct or ducted vent to outdoors.	Single vents should have 1 sq. inch for each 3000 BTUH input

- a. The occupant or homeowner must be informed of the installer's intentions.
- b. Dampers, grilles or registers installed for the purpose of controlling the supply airflow shall not be considered as obstructions in sizing calculations.
- c. All work shall be done in a professional workmanship manner and in accordance with UMC and agency weatherization specifications.

## 8.05 Evaluating Air Flow

1. To ensure proper operation, efficiency and durability of the forced air system, total system air flow must be measured on both new and existing systems. Adequate air flow must be determined by one or more of the following:
  - a. Temperature rise: System temperature rise should be evaluated to ensure it is within limits indicated on the data plate.
  - b. Static pressure: System total external static pressure should be evaluated to ensure it is within limits indicated on the data plate.
  - c. Flow plate.
  - d. Fan depressurization device such as a Duct Blaster. (SWS 5.3003.3a)
2. Total External Static Pressure (TESP): To ensure that the total external static pressure is not exceeded, static pressure should be measured on both the supply and return side and added together for a TESP. All newly installed forced air systems must have TESP measured and compared to manufacturers' specifications on the data plate. All newly installed equipment will not exceed manufacturer's TESP limits to the greatest extent possible. If manufacturer's TESP limit is not achieved, appropriate modifications will be documented to demonstrate the attempt at compliance. On existing equipment, measuring TESP is optional and measurements in excess of manufacturers' limits alone do not require delivery system modifications. On existing equipment, auditors may use a combination of factors such as temperature rise, TESP and high limit switch operation to determine if modifications to the delivery system are needed. When the manufacturers limits are not available, .5 inch WC must be used. (SWS 5.3003.3b)
3. Temperature rise: Inadequate air flow can cause supply temperatures to raise above the manufacturers acceptable limits. Temperature rise (supply temperature minus return temperature) must be measured and be within the manufacturers limits. When temperature rise limits are not known, 30° – 70° Fahrenheit must be used. (SWS 5.3003.3h)
4. New Ductwork: If new ductwork is installed, airflow must be verified tactilely at each register to ensure that adequate air flow is delivered. (SWS 5.3003.3e)
5. New forced air equipment: Any forced air equipment installed under the program must have a minimum of a MERV 6 filter installed on the system. (SWS 5.3001.2c)

## 8.06 Pressure Balancing

1. Room pressure testing is required whenever a forced air heating system is present. When room pressures exceed +/- 3 Pascals when measured with reference to outside and the room pressure imbalance causes a combustion safety issue, corrections to reduce pressures must be completed. Pressure imbalances can potentially cause building durability and infiltration/exfiltration issues. Therefore, it is allowable and encouraged, but not required, to mitigate pressures +/- 3 Pascals in situations where combustion hazards are not identified. (Variance-SWS 6.6201.2a)

For details on pressure testing, see Appendix Q, Room-to-Room testing Procedures. Many of the pressure balancing procedures listed below can be intrusive; inform occupant or homeowner of procedure prior to installing. The following is a list of possible correction procedures:

- a. Installer shall inform occupant or homeowner of proposed intentions to undercut door. This item shall include removing door, cutting the bottom, and rehanging the door so that it will open and close freely. Installer shall not scar, mar, or otherwise rendered door unusable. All work shall be done in a professional workmanship manner and in accordance with Uniform Mechanical Code (UMC) and agency weatherization specifications.
- b. Bypass grille installation shall include installer informing occupant or homeowner of proposed intentions. This item shall include installing non-closeable grilles opposite each other on each side of wall or door. Opening for grille shall be finished so that there are no unsightly holes or air bypasses. All work shall be done in a professional workmanship manner and in accordance with UMC and agency weatherization specifications.
- c. Installer shall inform occupant or homeowner of procedure prior to installing jump-over ducts. This installation shall include installing a crossover duct and connecting to bypass grilles, the duct shall be insulated flex duct with the seams sealed at the flex duct and the connector. Mastic shall be used after securing with screws. Duct tape is prohibited from sealing or securing duct and connector.



Through the wall bypass grille



Ceiling jump-over duct grille

## 8.07 Moisture Mitigation

1. Homes with moisture problems have created the need for increased testing and in some situations corrections are needed. Appendix H provides information on improving moisture problems. Occupant or homeowner is to receive and sign a copy of Moisture and Mold-Related Weatherization Procedures form (in Appendix I) and a copy shall be placed in the client file.

Moisture problems can be reduced or eliminated by ventilating areas where excessive moisture is produced, such as bathrooms and kitchens. This should include installation of a high quality exhaust fan in the home and informing the occupant of the related moisture issues and the proper operation and use of the fan. See section 9 for specifics on installing ventilation equipment.

(SWS 2.0401.1c)

2. Moisture problems can be reduced or eliminated by controlling the source of the moisture. This can involve:
  - a. Install 6 mil ground cover on a crawlspace floor.
  - b. Vent dryers to the outside of the building.
  - c. Seal the foundation.
  - d. Provide positive drainage away from foundation.
  - e. Repair the roof, flashing, gutter, and downspout.
  - f. Educate the occupant about the sources of moisture that they are able to control and the importance of maintaining drainage systems (gutters, downspouts, grading etc.), and floor ventilation.

(SWS 2.0401.1c, 2.0402.1c)

3. Furnish and install Energy Star™ or equivalent dehumidifier (minimum 25-35 pint). Installer shall leave manufacturer's instructions with the occupant or homeowner. The dehumidifier shall: (SWS 2.0404.1a, 2.0404.4a)
  - a. Be properly sized to maintain the humidity level as per Appendix H.
  - b. The equipment shall have a fan off option.
  - c. Retain settings after power off.
  - d. Controls must be labeled so they are understandable, readable and accurate for the occupants needs.
  - e. Equipment to be located in an unconditioned space shall be rated for cold temperature operation. (SWS 2.0404.1a)
4. Dehumidifier shall only be installed after the following conditions steps have been taken to control moisture:
  - a. Downspouts are redirected away from foundation.
  - b. Clothes dryer is vented to the outside.
  - c. Sump pump is covered and sealed (If applicable).
  - d. Exposed soil in crawl space is covered with a 6 mil ground cover.
  - e. Plumbing and /or roof leaks are eliminated. (SWS 2.0401.1b)
5. All dehumidifiers shall be installed to the following criteria:
  - a. Energy Star equipment must be installed according to manufacturer specifications and meet all applicable codes.
  - b. Equipment must be installed to permit adequate air flow
  - c. Drying must be provided for all basement areas. (SWS 2.0404.4b)
  - d. The dehumidifier must be connected directly to condensate line that drains to a plumbing drain or the exterior, away from the home's foundation and in compliance with the plumbing code or the authority having jurisdiction. If needed a condensate pump must be installed.
  - e. Any penetrations to the exterior of the home created by the installation of the appliance must be sealed.
  - f. Initial relative humidity and temperature settings must be set by the installer to ensure the space does not reach dew point.

- g. Operation of controls and needed maintenance must be reviewed with occupant. Controls must be labeled as to their function.
  - h. The user's guide, warranty information and installer contact information must be provided to the occupant.
  - i. Systems located in basements must be rated for cold temperature operation. (SWS 2.0404.1b, 2.0404.4a, 2.0404.4b, 2.0404.4f, 2.0404.4c)
6. Removed equipment must be recycled or disposed of properly in accordance with local regulations. (SWS 2.0404.1c)
7. The client must be educated on the use of the dehumidifier and how and when to change filter and clean condensate drain of the dehumidifier in accordance with manufacturer instructions. (SWS 2.0404.4f)

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## Section 9 : Mechanical Ventilation

### 9.01 General:

The Oregon WAP program follows ASHRAE 62.2 guidelines. The requirements of the current ASHRAE 62.2 must be met to the greatest extent possible. Ventilation levels must be determined by using the ASHRAE 62.2 formulas. The Appendix A – alternative compliance path must be used under the program. (SWS 6.6201.1c)

Mechanical ventilation is used primarily to replace inside air with fresh air from the outside. As homes are tightened to reduce energy costs, normal infiltration and exfiltration has been reduced. Therefore, we cannot rely on natural forces to provide ventilation at all times of the year. Mechanical ventilation helps lessen the amount of indoor air pollutants and moisture that becomes trapped in the home.

ASHRAE 62.2 requires calculations be performed to determine a whole building ventilation rate for the home. Ventilation rates must be calculated using formulas included in the current ASHRAE 62.2 standard.

Properly sizing fans installed under the program is critical. Over sizing fans can cause comfort issues and unnecessary energy penalties. Whole building continuous flow rates shall not exceed the calculated whole building continuous ventilation rates by more than 50 percent.

This section is not all inclusive of all ASHRAE 62.2 requirements. For complete details, refer to the current ASHRAE 62.2 standard.

### 9.02 System Type

1. Whole Building Ventilation: Whole building ventilation rates must be calculated on all projects and flow rates set at final inspection. Documentation of whole house ventilation calculations must be present in the job file. Final whole building flow rates that are 15 cfm or less do not require whole building ventilation.
  - a. Existing systems will be identified, visually inspected, and measured for airflow. Work orders will be developed to adjust the system according to the ASHRAE 62.2 standard. (SWS 6.6204.1a-e)
  - b. The whole building ventilation system may consist of one or more exhaust fans, HRV/ERV or supply air systems.
  - c. Local exhaust fans are permitted to be part of the whole building system.
  - d. Controls & operation: Controls must be provided to allow the whole house ventilation without intervention of the occupant. A readily accessible override control must be provided to the occupant. Controls must be labeled as to their

function. Wiring must be installed in accordance with original equipment manufacturer specifications, and local and national electrical and mechanical codes.

Controls must be used that can meet the following conditions:

- Run fan continuously or intermittently depending upon the intended schedule of operation
  - Operate fan to produce the intended flow for each intended flow setting.
- e. The whole house ventilation system may operate on a continuous or intermittent basis. Continuous run fans must be rated for continuous use.
- f. Sound Rating: Whole building ventilation or continuous local exhaust shall be rated for sound at a maximum of 1.0 sone. (SWS 6.6288.1a, 6.6202.1a-e & 6.6288.2a)
2. Local Exhaust Ventilation: A local mechanical exhaust system may be installed in bathrooms & kitchens if needed. Existing fans **do not** have to meet the fan flow requirements listed below.
- a. New bath fans installed must be either rated at 80 cfm on an intermittent basis or 20 cfm continuous run. It is allowable to install a fan operating continuously at 20 cfm without meeting the 80 cfm intermittent flow rate. (SWS 6.6201.1a, c & b)  
Note: 80 cfm requirement is an Oregon specific requirement and exceeds SWS and ASHRAE requirements.
- b. New kitchen fans installed must be rated at 150 cfm. Kitchen fans require the 150 cfm intermittent rate even if they are being utilized for continuous use at a lower flow rate. (SWS 6.6201.1a, c, & b)  
Note: 150 cfm requirement is an Oregon specific requirement and exceeds SWS and ASHRAE requirements.
- c. Kitchen fans installed require a range hood unless a ceiling mounted fan can provide a minimum of 5 kitchen air changes per hour.
- d. Control & operation: New bathroom local ventilation fans installed must have dehumidistat, delay off timer or similar means of automatic control.
- e. Sound Rating: Demand controlled local exhaust fans shall be rated for sound at a maximum of 3 sone, unless the maximum airflow exceeds 400 cfm. (SWS 6.6288.1b & 6.6288.2b)

### 9.03 Venting

1. Vent runs shall be as short as possible. Exhaust fans shall be equipped with an operating back-draft damper.
2. Smooth, rigid duct vent, must be mechanically fastened and shall meet venting requirements of ASHRAE 62.2 table 5.3 (see Appendix J). Ducts should not have traps or reversing horizontal runs. It shall be substantially airtight to the outside.
3. Smooth, rigid ducts must be connected and sealed to termination fitting as follows:
  - a. Round metal-to-metal must be fastened with a minimum of three equally spaced screws
  - b. Other metal-to-metal connections must be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, or tapes
  - c. Other specialized duct fittings must be fastened in accordance with manufacturer specifications
  - d. In addition to mechanical fasteners, duct connections must be sealed with UL 181B or 181B-M listed material. Fasteners must not inhibit damper operation (SWS 6.6002.2c)
  - e. Ductwork in unconditioned spaces must be insulated to a minimum of R-8.
  - f. A termination fitting with an integrated collar must be used. The collar must be at least the same diameter as the exhaust fan outlet; if collar is larger than exhaust fan outlet, a rigid metal transition must be used. Fitting must be appropriate for regional weather conditions and installation location on house so as not to be rendered inoperable (SWS 6.6002.2b)
4. Insulated flexible ductwork is allowed for bath and utility fan venting. Ductwork shall be a minimum 2" in diameter larger than the exhaust port of the fan. Ducts will be as straight as possible, fully extended, and have the shortest run possible. Horizontal runs will be supported in accordance with flex duct manufacturer specifications and local codes, but the supports shall be no more than 4' apart and shall be no less than 1.5" wide. Flexible duct to

- metal connections will be fastened with tie bands using a tie band tensioning tool. In addition to mechanical fasteners, duct connections will be sealed with UL 181B or 181B-M listed material. Fan flow will be verified by flow measurement to meet ASHRAE Standard 62.2. (SWS 6.6002.1c). A termination fitting with an integrated collar must be used. The collar must be at least the same diameter as the duct vent; if collar is larger than exhaust fan outlet, a rigid metal transition must be used. Fitting must be appropriate for regional weather conditions and installation location on house so as not to be rendered inoperable (SWS 6.6002.2b).
5. Vent terminations shall use screen material with no less than ¼ inch and no greater than 1/2 inch hole size in any direction. Installation must not inhibit damper operation or restrict air flow. (SWS 6.6002.2e)
  6. New terminations must be installed:
    - a. A minimum of 3 feet away from any property line.
    - b. A minimum of 3 feet away from operable opening to houses
    - c. A minimum of 10 feet away from mechanical intake.
    - d. As required by authority having jurisdiction. (6.6002.2f)
  7. Galvanized steel, stainless steel, or copper must be used for termination fitting for kitchen exhaust. (SWS 6.6002.2g)
  8. Installation of vent terminations must be weatherproof.
    - a. Exterior termination fitting must be flashed or weather sealed.
    - b. Installation must not inhibit damper operation.
    - c. Manufacturer specifications must be followed. (SWS 6.6002.2d)
  9. All existing fans must be vented to daylight using these requirements.
- 9.04** All fans intended for continuous use must have a sone rating of 1.0 or less. All fans used on an intermittent basis must have a sone rating of 3.0 or less. Existing fans do not have to meet sone requirements.
- 9.05** If an existing fan is to be used for continuous use, it must be rated for continuous use.
- 9.06** If the whole house mechanical ventilation is run on an intermittent cycle, flows must be increased in accordance with table 4.2 (see Appendix N) from the ASHRAE 62.2 standard.

### 9.07 Determining Air Flow

1. All existing exhaust fans must be flow tested to determine actual airflow.
2. If a fans air flow cannot be measured, the fans flow must be assumed to be zero.
3. All fans installed under the program must have flow rates measured and documented in the file. If the fan is used for continuous and local use than the flow rate of each mode must be measured separately.  
(SWS 6.6201a-c, 6.6204.1d, 6.6205.1g)

### 9.08 Room to Room Air Flow

1. Room pressures shall be measured for pressure imbalances in excess of +/- 3 Pascals.
2. Room pressures must be measured with reference to (WRT) outdoors with all interior doors closed and ventilation systems running.
3. If a room(s) exceed the 3 Pascal limit **and** the pressure imbalance causes a combustion safety issue, an appropriate means of pressure balancing must be installed (e.g. transfer grills, jumper ducts, individual room returns) (See section 8.03 for details on room pressure reduction).  
(Variance-SWS 6.6201.2a)

### 9.09 Other Requirements

1. Adjacent spaces: To prevent air movement between conditioned spaces and adjacent spaces such as garages, attics and crawlspaces, air sealing must be performed between the conditioned space and unconditioned areas. This will involve sealing all penetrations and applying seals (weather stripping) to access doors. Doors between dwelling units and common interior hallways must be weather stripped unless the ventilation system requires communication between the hallway and the conditioned unit.  
(SWS6.6003.5b)
2. Instructions and labeling: Instructions as to the proper operation and maintenance of the installed equipment must be supplied to the occupant. All

controls for continuous run fans must be labeled as to their function. Home owners shall be instructed on the operation and proper maintenance of the ventilation system. A label indicating the presence and purpose of the ventilation system must be included or a copy of the system operation guide must be posted at the electrical panel. (SWS 6.6202.1a-b, 6.6204.1f)

3. Clothes dryers: All clothes dryers shall be exhausted directly to the outdoors. (See Appendix I or 3.12). (SWS6.6005.1a)
4. Combustion and solid fuel appliances: When an atmospherically vented combustion appliance or solid fuel burning appliance are included anywhere in the structure, pre and post worst case combustion testing is required ensure that the appliances are drafting adequately or the housing depressurization limit (HDL) has not been exceeded. If either of these tests indicates a problem, then the exhaust fan flow may be reduced, pressure balancing the home or providing compensating outdoor air is allowed. (SWS 6.6003.5c, 6.6205.1e)
5. Space conditioning duct systems: Any ductwork located outside of the conditioned space, including but not limited to garages, crawlspaces and attics, must be sealed to obtain a total duct leakage to the outside of no more than 10 percent of the square footage when measured at 50 Pascals. If these levels cannot be achieved, there must be documentation in the job file as to why it was not obtained.

Note: When the duct leakage test is performed, if there are ducts in the garage, the door leading from the garage to the outside must be open.

6. Minimum filtration: All mechanically supplied outdoor air must pass through filter before conditioning. Filters must have a minimum efficiency rating value (MERV) of 6 or higher. Pressure drop across filter will match equipment capabilities. Filter systems that produce ozone will not be allowed. Filter must be located and installed to facilitate access and regular service by occupant/maintenance staff. Filter will be located on the inlet side of the equipment fan. Filter access panel will include gasket or comparable sealing mechanism and fit snugly against exposed edges of filter when closed to prevent air bypass. Filter plenum construction will be airtight and sealed to adjoining ductwork. (SWS 6.6202.9 a-d)
7. Carbon Monoxide Alarms: A Carbon Monoxide alarm shall be installed in each dwelling in accordance with ASHRAE 62.2 and manufacturer specifications as required by the authority having jurisdiction if an operable CO alarm does not exist. (SWS 2.0301.2a-b)

## Section 10 : Thermostats

- 10.01 General:** Thermostats shall be installed according to the provisions of current Oregon Building Code or other applicable codes and shall meet the requirements of the agency weatherization programs. Any exceptions shall be approved in writing in advance by the agency.
- 10.02** Thermostat installation may be recommended when deemed by the auditor to be necessary. A thermostat is important in ensuring that the heating system installed works optimally.

**Thermostats are available in two basic thermostat types:**

### **Line-voltage thermostats**

These thermostats are used in single heating systems including radiant systems and baseboards. Line voltage thermostats are installed in series with heaters, mostly at 240V. In this type of connection the current flows through the thermostat and into the heater.

### **Low-voltage thermostats**

Low-voltage thermostats are more efficient when it comes to the controlling of current flow. These thermostats are used in central heating systems that use electricity, gas and oil.

**Line-voltage and low-voltage thermostat options:**

**Programmable thermostats:** With a programmable thermostat the temperature in the home is automatically adjusted according to preset times. Programmable thermostats can be purchased in several models. The simpler ones allow you to program daytime and nighttime temperature settings while the more complicated ones can be programmed to adjust temperature differently for different days and times of the week.

Smart thermostats have the ability to auto program based on occupancy sensors and are WIFI enabled allowing them to utilize web access to increase adjust cycles based on outdoor temperatures. **Auditors may recommend programmable or smart thermostats if the client is capable and willing to use a setback thermostat.**

**Mechanical thermostats:** These are the cheapest and easiest thermostats that can be installed. They feature either vapor-filled bellows or bi-metallic strips, which respond to variations in temperature. Mechanical thermostats are often considered unreliable, particularly the cheapest models that make use of bi-metallic strips. The major disadvantage with these thermostats is the slow response of the bi-metallic strip, which may result in significant temperature variations either above or below the desired set points. **Mechanical thermostats are not recommended for use under the program.**

**Electronic thermostats:** Unlike mechanical thermostats, these thermostats make use of electronic components to detect temperatures and subsequently initiate control of the heating system. They are quicker in responding to temperature variations. Electronic thermostats can be either for line-voltage or for low-voltage purposes. Electronic thermostats may be either programmable or manual control.

**10.03** All thermostats replaced under the program must meet the following criteria:

1. Thermostats replaced should be electronic, if possible and may be either programmable or manual setback.
2. Programmable thermostats shall have at least two setback periods per day, with separate high and low temperature settings.
3. If used with heat pumps, a thermostat with supplementary heat lockout that can interface with an outdoor temperature sensor or web based weather stations should be selected. (SWS 5.3003.11f)

**10.04** Removal of existing equipment:

1. When being replaced. Mercury-based thermostat must be removed safely and disposed of in accordance with EPA regulations. (SWS 2.0103.2b)
2. Existing controls must be removed in accordance with EPA and USDOE lead safe work rules. (SWS 5.3003.11b)

**10.05** Installation

1. Thermostats shall be installed according to the manufacturer's instructions and in compliance with all state, agency, and local codes.
2. Penetrations for control wiring must be sealed with a durable sealant (e.g. caulk, silicone, foam) at both the interior (e.g. sheetrock) and exterior air barriers (e.g. Ceiling, floor or wall penetration) (SWS 5.3003.11c)
3. Mounting location for air leakage and conductance that would affect the thermostat operation (e.g., marriage walls, exterior walls) must be assessed. Thermostats that are exposed to extreme temperatures, radiant heat sources and drafts should be relocated. Wiring and any change-over costs is an allowable expense if authorized by the local agency. (SWS5.3003.11d)
4. Conventional Heat Pump applications:
  - a. An outdoor temperature sensor must be installed in accordance with manufacturer specifications. (SWS 5.3003.11j)

- b. Supplementary heat must be wired onto second stage heating terminal in accordance with manufacturer specifications (SWS 5.3003.11j)
- c. Supplementary heat lockout on air-to-air heat pumps must be set to the economical balance point. (SWS 5.3003.11g)
- d. For air-to-air heat pumps, low ambient compressor lockout must be set to 0°F outdoor temperature or ambient compressor lockout must be disabled. (SWS 5.3003.11g)

**10.06 Occupant Education (SWS 2.0702.2b, 5.3003.11o)**

- 1. Installer shall provide verbal operating instructions to the homeowner/renter and/or rental owner. Including:
  - a. Proper use of setbacks for the type of equipment installed.
  - b. Using emergency heat appropriately.
- 2. Installer shall leave the manufacturers manual with the homeowner/rental owner.

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## Section 11 : Water Heaters

**11.01 General:** Material shall be installed according to the provisions of current Oregon Building Code or other applicable codes and shall meet the requirements of the agency weatherization programs. Any exceptions shall be approved in writing in advance by the agency.

### 11.02 Water Heater Assessment

1. Combustion Testing must be performed on combustion type water heaters (See Section 8) (SWS 7.8103.1a)
2. The heater shall be inspected to ensure safety and efficiency. The inspection shall include checking the following:
  - a. Water or fuel leaks.
  - b. Damaged or improper wiring or electrical components.
  - c. Signs of venting issues. (e.g., soot, rusting of flue pipe, burned paint or wires)
  - d. Corrosion.
  - e. Temperature and pressure relief valve.
  - f. Assess the system for the addition of a potable water expansion tank. If the local water supplier requires a backflow prevention device, a potable water expansion tank must be installed. (See 11.16-5)
  - g. Assess the unit for additional tank insulation and water pipe insulation.
  - h. Measure the water temperature. (SWS 7.8103.1a-e)

### 11.03 Water Heater Measures

1. Water heater temperature shall be set to 120° with the clients' approval. In the case of an electric water heater, both the upper and lower thermostat must be adjusted. (SWS 7.8102.2k)
2. Tank Insulation.
3. Water pipe wrap.
4. Replacement.

#### **11.04 Water Heater Insulation General**

Note: Not all water heaters can be wrapped with additional insulation; check tank to see if a water heater warranty will be negated if additional insulation is installed. Do not insulate water heater if the units has a manufacturers warning against adding additional insulation. No water heater shall be wrapped which exhibits leaks or other evidence of impending failure. Water heaters located in conditioned space should not be insulated.

1. The water heater insulation wrap shall have an insulation value of R-11 or greater. The insulation wrap shall be faced with white vinyl sheeting with nominal thickness of four mils (minimum 3.2 mils). Tape used shall be compatible to the vinyl sheeting of the insulation wrap.
2. The vinyl shall be continuously laminated to the fiberglass blanket and shall have a flame spread rating of no more than 150 when tested in accordance with ASTM E-84-88.
3. All access panels must be clearly marked to allow for future access.
4. Insulation shall be neatly cut and removed from temperature relief and drain valves.
5. All seams must be taped with compatible vinyl tape.
6. Insulation shall be secured at a minimum of 3 places using wire or vinyl tape. Vinyl tape shall form 2 complete wraps around the water heater.
7. Water heaters without operable pressure relief valve shall have a pressure relief valve installed and extended to within 6 inches of floor; relief pipe shall not be threaded on bottom end. (SWS 7.8102.2f,i)

#### **11.05 Gas Water Heaters**

1. Insulation shall be kept at least 2 inches away from the access door and burner.
2. Insulation and tape shall be kept at least 3 inches away from controls, access panels and/or air Intakes.
3. The top of a gas fired water heater shall not be insulated and must be cleaned before applying tape.

4. Bottom of insulation shall be at least 3 inches from bottom of water heater and be at least 3 inches from the burner access door in order to leave combustion air passage.
5. Pilot light and controls must be accessible.

#### **11.06 Electric Water Heaters**

1. Set both upper and lower thermostats to 120° before insulating water heater.
2. Insulation may cover the top of the water heater if the insulation does not obstruct the pressure relief valve.
3. Insulation shall be kept at least 2 inches away from the power supply.

#### **11.07 Pipe Insulation**

1. Starting at the water heater (located in unconditioned space), at a minimum wrap the first 6 feet on both the cold and hot water pipe with R-3 pre-split foam water pipe wrap, or wrap with R-11 fiberglass insulation and secured with twine, zip ties or wire.
2. When installing the water pipe insulation in connection with the water heater insulation wrap, the water pipe insulation shall not be installed in a position to interfere with or be within 6 inches from the gas water heater draft hood and/or single wall flue pipe or 3 inches if the flue pipe is made of B Vent. (SWS 7.8102.2i)

#### **11.08 Water Heater Replacement**

1. New water heater and associated components shall be installed by a licensed contractor to accepted industry standards, in accordance with the local code and manufacturer specifications. (SWS 7.8102.2b, c)
2. Water heaters may be replaced under the following conditions:
  - a. Water heater is non-operational.
  - b. The storage tank leaks.
  - c. The water heater leaks at one or more of its fittings, valves or heating elements and a permanent water tight seal cannot be made.

- d. Excessive sediment has built up in the tank and cannot be flushed out.
- e. The water heater replacement is cost effective.

### **11.09 Water Heater Selection**

1. Equipment must provide sufficient, affordable, safe, and healthy hot water for the occupant in accordance with IRC P2801. Potential for health and safety hazards (e.g., back drafting, flame rollout, obstructions) must be assessed in selecting equipment. (SWS 7.8102.1a)
2. If a combustion based system is selected and the water heater is located inside the conditioned space, it must be either direct vented or power vented and have an energy factor (EF) of .58 or better. (Variance SWS 7.8102.1a)
3. Combustion water heaters installed in unconditioned areas may be natural draft and must have an energy factor (EF) of .58 or better.
4. Combustion water heaters must include a low nitrogen oxide burner.
5. Electric water heaters must have an energy factor of at least 0.93.

### **11.10 Water Heater Replacement Specifications**

1. Remove old water heater and associated components in accordance with local codes.
2. Seal off any unused chimney openings or penetrations.
3. Any existing water leaks must be repaired before installation begins.
4. If possible, an emergency drain pan shall be installed with sides that extend a minimum of 4 inches above floor if leakage would cause damage to the home. A  $\frac{3}{4}$  inch drain line or larger must be connected to tapping on pan and terminated in accordance with local code.
5. In the case where the local water supplier requires a backflow prevention device to be installed on the water supply (closed water system), a potable water expansion tank shall be installed on the cold water side. A direct connection with no valves between the storage tank and expansion tank must be installed in accordance with local code and according to manufacturer specifications.

6. A temperature and pressure relief valve must be installed in compliance with local codes and according to manufacturer specifications. Temperature and pressure relief valve discharge tube must be installed in accordance with the IRC.
7. Dielectric unions, if needed, must be installed in accordance with local codes and according to manufacturer specifications.
8. If not provided by the manufacturer, heat traps must be installed on the inlet and outlet piping.
9. Discharge temperature must be set not to exceed 120°. (SWS 7.8102.2a-k)

#### **11.11 Commissioning of the water heater**

The following must be checked once the system has been filled and purged:

- Safety Controls.
- Combustion safety and efficiency. ( If applicable)
- Operational controls.
- Fuel and water leaks.
- Compliance with local code requirements. (SWS 7.8102.2i)

#### **11.12 Occupants must be educated on the safe and efficient operation and maintenance of the system, including:**

- Adjustment of water temperature and target temperature.
- Periodic drain and flush.
- Expansion tank and backflow preventer.
- Periodic inspection, maintenance or replacement. (SWS 7.8102.2h)

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## Section 12 : Manufactured Home General Installer Requirements

- 12.01 General:** Material shall be installed according to the provisions of current Oregon State Manufactured Dwelling Administrative Rules or other applicable codes and shall meet the requirements of the agency.
- 12.02** Insulation safety standard shall be installed according to the provisions of the Federal Mobile Home Construction and Safety Standard, Title 24, CFR 3280, the Uniform Building Code, other applicable codes, and the requirements listed below.
- 12.03** Insulation flame spread of materials used shall meet the flame spread and smoke developed requirements of Sections 1713 and 1714 of the 1991 UNC. Only blown fiberglass insulation is allowed in mobile home ceiling cavities.
- 12.04** Only non-combustible insulation tested to ASTM 136-92 may contact masonry chimney. This includes existing insulation.
- 12.05** Before installing a single ply membrane roof, the three-tab roofing must be removed completely.
- 12.06** Electrical Safety
1. Rigid fill tubes must be made of a material that will not hold an electric charge, such as Schedule 40 PVC Electrical Conduit, or be grounded. For an additional level of protection, the metal coupler on the hose should be connected to the grounding wire. The grounding wire should be connected to a grounding rod driven into the ground as far as possible.  
(SWS 2.0602.1a, 2.0602.2b)
  2. If aluminum wiring is present and/or issues are identified with the homes electrical system, work may not proceed until the suspect wiring is inspected and determined to be safe by a licensed electrician.  
(Variance SWS 2.0602.2d, 2.0602.2a)

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## Section 13 : Water Heater Closet

**13.01 General:** All water heater closets with exterior accesses must be assessed during the energy audit. The water heater closet should be assessed for accessibility, plumbing leaks, structural integrity and penetrations. If a combustion type water heater is installed, the space should be treated as an unconditioned space if possible. Depending on the results of the assessment, the water heater closet may be treated as either a conditioned or unconditioned space.

**13.02 Conditioned Space:** This section only applies to electric water heaters and combustion water heaters that are direct/power vented. Natural draft combustion water heaters must be isolated from the conditioned space. If it is possible to insulate and weather-strip the access door, then the water heater closet should be treated as a conditioned space. If the water heater closet is being treated as a conditioned space, the water heater shall not be insulated. At minimum, the following shall be completed:

1. The exterior access door shall be insulated and weather-stripped. The access door shall be insulated to a minimum of R-11 if clearance allows.
2. Adjacent open framed exterior walls must be insulated to a minimum of an R-11.
3. All penetrations through the ceiling, floor, and exterior walls of the closet must be sealed with approved materials. (See section 18)



Water heater/bathtub penetration



Water heater closet door insulated with foam board

4. If air vents are present on either the access door or adjacent wall, they must be sealed.

**13.03 Unconditioned Space:** If it is not possible to weather-strip and insulate the water heater door or the closet contains a natural draft water heater, the following must be completed to isolate the closet from the conditioned space:

1. The tank should be wrapped with an insulation blanket if the manufacturer allows. (See section 11)
2. All holes that allow air leakage to the interior must be sealed. (See section 18)
3. If there is adequate access and clearance, Interior walls must be insulated to a minimum of an R-11.
4. If the water heater is a combustion type water heater, if testing shows combustion air to be inadequate, additional combustion air must be provided. Combustion air supplies that go through the floor must be labeled for identification and must not be blocked or sealed.
5. Blower door zonal pressure diagnostics must be performed to verify isolation has been achieved. (SWS 2.0201.2a, 2.02041b, 3.1301.1d)



## Section 14 : Manufactured Home Roof Cavity

**14.01 General:** Material shall be installed according to the provisions of current Oregon Building Code or other applicable codes and shall meet the requirements of the agency weatherization program. Any exceptions shall be approved in writing in advance by the agency. Presence of lead based paint in pre-1978 homes must be assumed unless testing confirms otherwise. (SWS 2.0102.1d, 4.1003.15a-g)

A dated insulation certificate signed by the installer must be provided that includes:

- Insulation type
- Coverage area
- R-value
- Installed thickness
- Number of bags installed in accordance with manufacturer specifications (for blown in only)
- A copy of the insulation certificate must be included in the project file. (SWS 4.1002.2c)

**14.02** Depending upon the type of roof or cavity, agency approved materials include insulation, shields for heat producing fixtures and ventilation, attic ventilation devices, roof sealant, etc.

**14.03** Insulation materials shall meet the flame spread and smoke developed requirements.

**14.04** All penetrations through the ceiling (e.g. marriage lines, closets, electrical and plumbing penetrations, and all gaps between exhaust fans, swamp coolers, and the envelope) shall be sealed before insulation is installed. The vertical clearance that existed prior to the single ply membrane roof installation for all vents and flues shall be maintained after the single ply membrane roof is installed.



- 14.05** Non-rated recessed lighting fixtures or fan/light combinations shall be shielded with solid flame resistant material. Refer to specification 1.08.  
(SWS 4.1001.1b)
- 14.06** Recessed fluorescent fixtures with thermal protection may be covered with insulation.
- 14.07** Install shields around all lights and heaters that do not meet the requirements of 1.07 or 14.05 heat-producing fixtures. The shields shall be a solid, flame-resistant material that is attached to the ceiling structure and provides a minimum clearance of 3 inches and a maximum clearance of 4 inches. Fiberglass batts DO NOT meet this requirement.
- 14.08** All existing and added insulation shall be kept at least 3 inches away from single wall metal flues by using shielding material. (SWS 4.1001.3b)
- 14.09** Wood stove chimneys shall have clearances maintained per manufacturer's instructions or local code; whichever is more restrictive. Manufactured chimneys (i.e."Metalbestos" or Type B vent) shall be shielded like any heat-producing fixture. All insulation shall be kept a minimum of 3 inches from metal flues.  
(SWS 4.1001.3b)
- 14.10** Installer shall close off and seal all ceiling registers and the return air opening in the ceiling of the furnace closet. See Section 17.06 for providing return air.

#### **14.11 Interior Ceiling Blow Access Method**

1. Installers shall protect and cover the floors and furniture.



2. Holes shall be evenly spaced and in straight line. Holes shall be drilled two feet in from each edge and another hole in the center of each truss cavity.
3. A plug shall be installed in each hole with sealant between the plug and the ceiling to stop air bypasses to the roof cavity.

## 14.12 Ventilation

For pitched roofs with an air space above the insulation: attic ventilation may be increased.

## 14.13 Exterior Roof Insulation

1. Three-tab roofing must be removed before installing single ply membrane roofing. (SWS 4.1002.1b)
2. Use rigid extruded polystyrene or rigid polyisocyanurate insulation, single ply membrane roof covering with a minimum thickness of 45 mil rubber, rubber boots, extend plumbing stacks, fender washers, screws long enough to achieve positive penetration, butyl tape and termination bar.
3. The installer is responsible for determining that the ceiling system is structurally adequate to support the combined weight of all materials imposed on the ceiling and for all damage occurring during installation, leaks caused by improper sealing, and damage due to combined weight of materials on the interior ceiling. If insulation is installed on the exterior of the roof cavities: all crank vents used for ventilation shall be removed.
4. Holes, gaps, and penetrations in existing roof deck must be sealed. (SWS 4.1002.2a)
5. Remove existing exhaust fan termination, flashing, or other objects that would interfere with installing the rigid insulation.
6. Insulate roof cavity to the highest R-value achievable.



7. Insulation must be installed according to manufacturer specifications without gaps, voids, compressions, misalignments, or wind intrusions. Insulation must be installed to prescribed R- value. (SWS 4.1002.2b)
8. The rigid insulation shall be mechanically fastened using screws with 3 inch galvanized deck washers. All screws shall penetrate the roof structure (trusses) a minimum of  $\frac{3}{4}$  inch to ensure insulation remains in contact and minimizes independent movement. All rigid insulation shall fit tightly together with no gaps to prevent thermal boundary breaks.



9. New roof coverings shall:
  - a. Be installed in accordance with manufacturer specifications and local building code requirements after installation of above roof deck insulation. (SWS 4.1002.1b)
  - b. Be extended down the wall and over the top edge of the wall covering and be secured to the wall using non-corrosive, self-tapping hex-head with a minimum length of 1- $\frac{1}{4}$  inch metal screws with butyl tape installed between the termination bar and the roof covering. Screws must be installed using all manufactured holes in the termination bar and must not be spaced any wider than 6”.
  - c. Roof insulation and covering shall be sufficiently rigid to prevent “ponding” of water on the surfaces after installation



10. All plumbing vents, kitchen fans, bath fans, wood stoves, and other fixtures are required to vent to the outside of the new roof and be adequately flashed and sealed. All vents and chimneys shall be extended through the new roof with quick disconnects. If a swamp cooler or a vent is to remain in place after the insulation and covering is installed, it shall be adequately flashed and sealed. If swamp cooler is removed, patch hole in an approved method.

11. All pre-existing roof drainage systems shall function properly after the insulation and the new roof covering have been installed.

## Section 15 : Manufactured Home Wall Insulation

**15.01 General:** Material shall be installed according to the provisions of current Oregon Building Code or other applicable codes and shall meet the requirements of the agency weatherization program. Any other exceptions shall be approved in writing in advance by the agency. Lead and asbestos safety procedures must be followed. (SWS 4.1101.1a)

Wall cavities must be inspected for moisture damage, pest locations, and integrity of the wiring, and holes to the interior. Location of belt rails, obstructions, and existing insulation must be identified. All interior surfaces of exterior walls must be inspected for loose paneling joints, occupant wall hangings, location of switches and outlets, and other wall obstructions. Objects must be removed from the interior surfaces of the walls being insulated and Interior paneling must be repaired as necessary. (SWS 4.1104.1b, 4.1104.2b, 4.1104.1b)

Upon completion of weatherization work, a signed and dated insulation certificate indicating square footage insulated, R-value installed, type of insulation and bag count shall be posted at the job site. The number of bags installed will be confirmed and will match the number required on the coverage chart. In addition, a coverage chart must be posted on the jobsite. A copy of the insulation certificate must be included in the job file (SWS 4.1104.1g, 4.1104.2g)

**15.02** Insulating cavities with wall heaters is prohibited unless fire stops are present.

**15.03** Materials vary depending upon the type of installation and may include agency approved insulation, fill tube, batt stuffing, corrosion-resistant screws, polyethylene, and caulking.

**15.04** Only non-combustible insulation tested ASTM-136-82 shall be installed in cavities adjacent to masonry chimneys.

**15.05** Exposed insulation facing material shall meet flame spread and smoke development requirements of section 1713 and 1714 of the 1991 UNC.

### **15.06 Blowing in/Batt Stuffing Methods**

1. Insure that both interior and exterior materials of the walls to be insulated are in good repair and well attached. Visually inspect for dry rot, pest infestation, water leaks, or other problems.

2. A self-tapping screw shall be installed through each crimp joint in the exterior metal siding 3-5 inches from the bottom of the wall to prevent panel separation.
3. Wall-to-wall attachments (bonding straps, screws, bolts, etc.) shall be secured or repaired.
4. Access to wall cavities
  - a. If skirting overlaps siding, skirting must be detached to allow access to the wall cavity.
  - b. Fasteners must be removed from the bottom of the siding, working upward until the siding can be pulled away from the framing approximately 6 inches without damaging the siding.
  - c. Temporary fasteners must be installed near the bottom of the siding panels at the seams to prevent separation.
  - d. If sub-sheathing is present under the siding, access through the sub-sheathing will be required. (SWS 4.1104.1a, 4.1104.2a)

#### **15.07 Blowing in Method**

1. Blowing machine pressure test must be performed with air on full, feed off, and gate closed. Hose outlet pressure will be set to 80 inches WC. (SWS 4.1003.15c, 4.1104.2c)
2. Insulation must meet a flame spread rating of 25 or less and a smoke development rating of 450 or less when tested in accordance with ASTM E84. (SWS 4.1104.2d)
3. Installation (SWS 4.1003.15d):
  - a. Insulation must be installed to a density of 1.5 to-1.6 pounds per cubic foot.
  - b. Using fill tube, 100 percent of each cavity must be filled to a consistent density.
  - c. Fill tube must be inserted from the bottom of the wall cavity within 6 inches of the top of the cavity between the interior paneling and any existing insulation.
  - d. Insulation shall be installed between the interior side of the existing insulation and the interior wall. (SWS 4.1104.2d)

## 15.08 Batt Stuffing Method

1. A sheet of polycarbonate, such as Lexan, must be cut to the following specifications to create a stuffer tool:
  - Approximately 1 foot x 8 feet x 1/4 inch with a 5 degree bend 7 feet 1/2 inch from the bottom.
  - All corners of the Lexan (polycarbonate) must be rounded and all edges must be sanded.  
Other clear sheet plastics must not be used due to a tendency to shatter under stress. (SWS 4.1104.1c)
2. Installation
  - a. Thickness of the batt must fill the void without deforming siding or damaging structure.
  - b. Fiberglass batts must fill the cavity (e.g., batt may be cut approximately 1 inch longer to ensure proper fill and allow for lap at the top)
  - c. A flexible membrane (e.g. polyethylene) must be cut 2 inches wider than the cavity and approximately 1 foot longer than the batt
  - d. Note: A poly-encased fiberglass batt may be used in place of the fiberglass batt and membrane assembly
  - e. Stuffer tool, membrane, and fiberglass batt must be aligned for installation. Membrane must be installed inserted between the interior wall and the fiberglass batt. Stuffer tool will be used to install the fiberglass batt and membrane at the same time.
  - f. Excess fiberglass batt and membrane vapor retarder extending below the cavity will be rolled and tucked into the cavity. (SWS 4.1104.1d)
3. Wall insulation completion
  - a. Sub-sheathing must be patched or repaired as necessary.  
(SWS 4.1104.1e, 4.1104.2e)
  - b. Re-attachment of skirting and siding.
    - 1) If skirting was removed, skirting must be reinstalled to shed water to the outside of the skirting.
    - 2) Siding must be reattached with corrosion-resistant sheet metal screws and siding must not have any bulges or wrinkles. Tapered screws such as wood screws or drywall screws are prohibited.  
(SWS 4.1104.1f, 4.1104.2f)

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## Section 16 : Manufactured Home Floor Insulation

**16.01 General:** Material shall be installed according to the provisions of current Oregon Building Code or other applicable codes and shall meet the requirements of the agency weatherization program. Any other exceptions shall be approved in writing in advance by the agency. Assessment of the project shall consist of inspecting the crawlspace for accessibility, leaks, standing water, drainage, sewage leaks and pests. (SWS 4.1302.1a, 3.1303.2a, 2.0402.1a)

If standing water in the crawlspace is an issue, drainage systems (gutters and downspouts, grade etc.) must be reviewed and addressed before floor insulation may be completed. Any drainage repair issues must be treated as an incidental repair. Major drainage issues are beyond the scope of the program. (SWS 2.0402.1b)

Upon completion of weatherization work, a signed and dated insulation certificate indicating square footage insulated, R-value installed, type of insulation and bag count shall be posted at the job site. A copy of the insulation certificate must be included in the job file. (SWS 4.1303.2e, 4.1303.1e)

**16.02** Before any work may commence, any installation or stabilization deficiencies that may affect worker health & safety must be addressed and repaired. (SWS 2.111.5a-b)

### 16.03 Material Requirements

1. Insulation materials must be of minimal water absorbency and be non-corrosive. (SWS 4.1303.1d, 4.1303.2d)
2. Flame spread index of selected materials must not exceed 25 with an accompanying smoke-developed index not to exceed 450 when tested in accordance with ASTM E84 or UL 723. (SWS 4.1303.1d)
3. Flame spread index of foam insulation must not exceed 75 and a smoke-developed index of no more than 450 when tested in the maximum thickness intended for use in accordance with ASTM E84 or UL 723 (SWS 4.1303.1d).
4. Foam insulation must be separated from the interior of the building by an approved thermal barrier at a minimum of 1/2 inch gypsum or a material that is tested in accordance with the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of ASTM 275. (SWS 4.1303.1d)
5. Fasteners must be corrosion resistant (SWS 4.1303.1d, 4.1303.2d)



- 16.04** Structural members and components shall be sound and free of insect infestation, dry rot, decay and other damage before measures are installed. Any repairs shall be completed before the insulation is installed. (SWS 3.1301.2a)
- 16.05** Operating combustion air intakes penetrating through the belly board shall not be blocked or sealed and must be labeled for identification. (SWS 3.1301.1d)
- 16.06** Electric forced air or heat pumps with air intakes penetrating through the belly board shall be sealed.
- 16.07** All gaps, holes, joints, and seams shall be sealed before installing underfloor insulation. Inspect all HVAC ducts and plenums for leaks and openings. Backing must be provided as needed to meet specific characteristics of the sealant and the penetration. (SWS 3.1301.1d)

Note: See the Air Sealing Section 18 for more information.

- 16.08** All gaps around plumbing penetrations through the subfloor and belly board (bathtubs, clothes washers, sinks, etc.) shall be sealed before installing underfloor insulation. Materials must be selected to comply with Oregon Residential Specialty and Manufactured Dwelling Installation Specialty Codes. Surface preparation and material selected must be used or installed in accordance with product manufacturer specifications. (Variance SWS 3.1301.1e)
1. Penetrations through soft bottomed belly board: Patching material must be provided as needed and shall be patched with a material of equal or greater strength than the existing rodent barrier/belly board, specific characteristics of the bottom board material and the characteristics of the hole. Patch must have a service life of a minimum of 20 years. (SWS 3.1301.1b)
  2. Penetrations through hard bottomed belly board: Patching must be provided as needed to meet both the specific characteristics of the bottom board material and the characteristics of the hole. Patch must not bend, sag, or move once installed. Patch must last for the life of the structure. (SWS 3.1301.1c)

3. Penetrations through sub-floor:

- a. Floor air sealing: Backing must be provided as needed to meet the specific characteristics of the selected sealant and the characteristics of the penetration. The backing or infill must not bend, sag, or move once installed. (SWS 3.1301.2b)
- b. Sealant selection: Sealants will be used to fill holes no larger than recommended by manufacturer specifications. Sealants must be compatible with all adjoining surfaces. Sealants must have no gaps and meet fire barrier specifications, if required. Only noncombustible materials must be used in contact with chimneys, combustion exhaust vents, and flues. (SWS 3.1301.2c, f)
- c. Sub-floor repair: Floor repair material utilized must meet or exceed strength of existing floor material and comply with manufactured housing rules and regulations. Repairs of more than 144 square inches must span from joist to joist and blocking added as needed to support the repair. The floor repair shall be securely fastened and air sealed. (SWS 3.1301.2d, e)

**16.10** All exhaust ducts (kitchen ranges, dryers, etc.) and condensation lines shall be extended outside the perimeter of the mobile home.  
(SWS 6.6005.2b-c, 6.6005.1a)

**16.11** Appliance exhaust fan vents (e.g. exhaust fans, kitchen range exhaust etc.) shall terminate outside the residence using manufactured duct and be equipped with a back-draft damper. Any new ducts installed under the program shall be made of rigid metal with smooth interior surfaces. Whenever possible; Ducting shall be supported with a downward slope at every connection. Bends or reversing horizontal runs in ducts shall be eliminated if possible. All exhaust ducts located in an unconditioned space must be insulated to an R-8. Kitchen range exhaust fan ducting shall meet the material standards in Section 1.10-3.

### **16.12 Water Pipes**

1. Exposed water pipes shall be insulated with R-3 pre-split foam or R-11 vinyl covered insulation in a human contact area or where water pipes are in contact with the ground. R-11 unfaced fiberglass batts are acceptable in a non-human contact area. If required by agency, drain traps shall also be insulated using R-11 unfaced batts. (SWS 7.8104.3d, 4.1303.2c)
2. Before installation, the installer shall ensure pipes are in satisfactory condition to receive insulation, are free from water leaks, and are properly secured to support the weight of the pipes and insulation. If problems are found, such as leaks or improperly supported pipes, the agency shall be notified before insulating that section of pipe.

3. Pre-formed pipe 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. Wrap joints that do not fit tightly, such as T-joints and elbows, with batt insulation. Installer shall use the correct inside diameter size insulation for the pipe being insulated (e.g. it is not permissible to use 1 inch preformed pipe wrap on 1/2 inch pipe). The lengthwise slit shall be positioned on horizontal pipe so that the slit is on the bottom side of the pipe. Twine, galvanized wire, or non-slipping plastic ties shall be used to secure the insulation. The ties shall be spaced starting at 1 inch from each end of the material and thereafter approximately every 12 inches.
4. Water pipes insulated with unfaced fiberglass insulation shall be firmly secured to the water pipes without unduly compressing the insulation. A minimum of R-7 (or about 2 1/2 inches in depth) shall be maintained after the pipe insulation is complete. The insulation shall be secured in place by polypropylene nylon twine, galvanized wire, or non-slipping plastic ties. The securing method shall be spaced at 2 inches from each end of the material and thereafter approximately 12 inches. Use fiberglass insulation when water piping runs next to a beam or joist.

### **16.13 Ground Cover**

1. If a new ground moisture barrier is required per agency work order, it shall be minimum 6-mil black polyethylene or its equivalent in perm-rating, strength and resistance to soil chemical degradation. (SWS 2.0403.4b)
2. When seams exist, they must be overlapped a minimum of 12 inches using "reverse" or "upslope lapping" technique. The ground moisture barrier shall cover all earth but shall not contact any wood members. (SWS 2.0403 .4c)
3. Ground moisture barrier may be fastened to ground with durable fasteners or ballast(s) if exposed to wind effects or the ground slope will cause movement of the ground moisture barrier. (SWS 2.0403.1d)
4. 100 percent of all exposed soil shall be completely covered with no rips or tears in the cover. New cover may be placed over the old ground cover. (SWS 2.0403.1b)
5. All debris, including organic material and any debris that may cause injury or puncture the ground moisture barrier, shall be removed, as possible, from the crawlspace before the new ground cover is installed. Debris removed must be disposed of appropriately.

## 16.14 Dryer Vents

1. All dryers must be vented to the outdoors and terminated with an operable dryer vent hood. Outdoors does not include unconditioned spaces such as attics and crawlspaces that are ventilated with the outdoors (SWS 6.6005.1a)
2. The operable dryer vent hood must include a backdraft damper. The outlet must be sealed to prevent water and air intrusion. (SWS 6.6005.3c)
3. Dryer vent ductwork must be smooth surfaced, rigid sheet metal, supported at each connection in the crawlspace and vented to daylight utilizing the shortest run possible. Use of elbows should be limited to the least possible number to ensure unobstructed venting. Plastic venting is not allowed. (SWS 6.6005.1a)
4. All joints must be sealed using UL – 181 tape (metal tape). (SWS 6.0005.1a)
5. Connections to the dryer and the dryer vent hood must be secured with a clamp as well as sealed with UL 181 tape. (SWS 6.6005.1a)
6. Flexible metal vent pipe may be used between the dryer and the hard pipe connection if it does not exceed three feet in length. The connection between the flexible metal and rigid metal vent pipe must be secured with a clamp as well as sealed with UL 181 tape. (SWS 6.0005.1a)
7. Dryer vent pipe must not be installed with sheet metal screws or other intrusive fasteners that will collect lint. (SWS 6.6005.1a)
8. Whenever possible, the dryer vent must be installed with a downward slope to the outside to allow for condensation drainage.
9. Dryer vents exceeding 35 foot in duct length must have a dryer booster fan installed. (SWS 6.6005.1a)
10. Occupant must be instructed to keep lint filter and termination fitting clean. If applicable, occupant must be instructed to keep dryer booster fan clean, if present. (SWS 6.6005.1e)

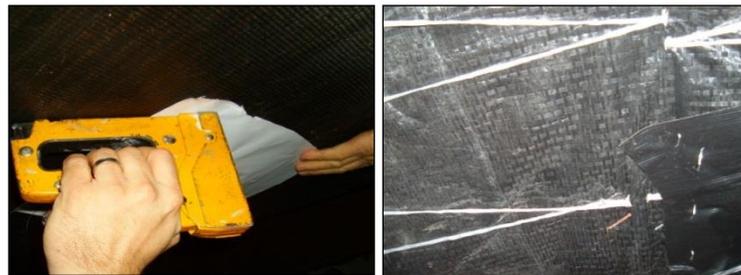
## **16.15 Belly board/rodent barrier preparation:**

1. Where belly board/rodent barrier is missing or damaged and accessible, the following must be ensured:
  - a. Ductwork must be sealed and insulated. See Section 17 for specifics. (SWS 4.1302.1b)
  - b. Holes in subfloor must be sealed. (SWS 4.1302.1b)
  - c. Accessible gas, water, and electrical lines secured at least every 4 feet to a floor joist or framing member. (SWS 4.1302.1b)
  - d. Water line must be located on the warm side of the insulation; if not, the water lines must be insulated appropriately. (SWS 4.1302.1b)
  - e. No water or gas leaks are present. (SWS 4.1302.1b)
  - f. Waste lines are sloped to 1/4 inch per foot. (SWS 4.1302.1b)
  - g. Belly board/rodent barrier is sound/strong enough to support insulation. (SWS 4.1302.1b)
2. When belly board/ rodent barrier is intact, the following must be ensured:
  - a. Holes and penetrations in the bottom board and subfloor are sealed. (SWS 4.1302.1b)
  - b. No water or gas leaks present. If leaks are identified, the belly board/ rodent barrier must be cut to access and repair the leak(s) before any work is completed. (SWS 4.1302.1b)
  - c. Belly board/rodent barrier is sound/strong enough to support insulation. (SWS 4.1302.1b)

## **16.16 Blowing Insulation through Belly Board/Rodent Barrier Method 3.1301.2d**

1. All tears, holes or other damage to the rodent barrier/belly board shall be patched with a material of equal or greater strength than the existing rodent barrier/belly board, and stapled in place using an outward clinch stapler, (e.g. stitch stapler). Holes in excess of 9 square feet shall be supported to secure the patch. Large holes in the barrier/board may be insulated with batts if the batts are protected with a material of equal or greater strength than the existing rodent barrier/belly board material and they do not interfere with the blowing operation. (SWS 4.1303.1b)

- a. All penetrations shall be sealed prior to installing insulation.
  - b. Patches over 9 square feet shall be stapled with a stitch stapler and twined with polypropylene or polyester twine shall have a breaking strength of at least 150 pounds. Smaller patches need only be stapled with a stitch stapler.
  - c. Support the air barrier with twine attached at every point it crosses a stud. Attaching twine shall not exceed 12 inch on center.
  - d. Twine shall be installed in a zigzag pattern not to exceed 12 inches.
  - e. 5/8-inch staples of at least 18 gauge corrosion resistant materials shall be used to attach twine.
  - f. The air barrier shall be cut in an “X” pattern in each cavity.
  - g. Each cavity must be insulated with blown-in fiberglass to specified R-value and density. The number of bags installed must be confirmed and must match the number required on the coverage chart. (SWS 4.1303.1a,c)
  - h. Flame spread index of foam insulation must not exceed 75 and a smoke-developed index of no more than 450 when tested in the maximum thickness intended for use in accordance with ASTM E84 or UL 723. (SWS 4.1303.1d)
  - i. It is recommended to seal all patches with an adhesive in addition to the previously stated specifications.
2. Insulation shall be in contact with the sub-floor and each joist cavity shall be completely filled. Insulation shall be blown to the proper density and R-value. (SWS 4.1303.1a)





### **16.17 When blowing in insulation through rim joists:**

Each cavity shall be drilled, filled and wooden plug inserted and glued to complete the application.

### **16.18 Installing Batt Insulation**

1. Any remnants of previous belly board/ rodent barrier and insulation shall be removed and properly disposed of. (SWS 4.1303.2b)
2. Minimum R-value of R-25 batts shall be installed. Lower R-value batts may be installed with agency permission.
  - a. If batts have a facing, the facing must face the conditioned area. (SWS 4.1303.2c)
  - b. Insulation shall be in contact with subfloor to prevent convection above the insulation. (SWS 4.1303.2c)
  - c. Insulation must not have gaps, voids, or be compressed. (SWS 4.1303.2c)
  - d. Insulation must be notched around all wires, pipes, and blocks. (SWS 4.1303.2c)

### **16.19 Insulation support for batts:**

1. Insulation shall be twined with polypropylene or polyester twine shall have a breaking strength of at least 150 pounds.
2. Support the insulation with twine attached at every point it crosses a stud. The twine shall be attached at every point where it crosses a joist or beam. The maximum spacing for the support mechanism with 24 inch on center or greater floor joist spacing shall not exceed 12 inch on center. Shorter spans shall not exceed 18 inch on center.
3. 5/8 inch staples of at least 18 gauge corrosion resistant materials shall be used to attach twine. (SWS 4.1303.2c)

## 16.20 Air Barrier

1. When feasible, a rigid air barrier (e.g. rigid insulation) shall be installed in contact with the joists. (SWS 4.1303.2c)
2. Rigid air barrier must be fastened as to not sag, bend, or fall off. The air barrier shall be secured at the perimeter and at each joist with the distance between fasteners not to exceed 18". (SWS 4.1303.2c)
3. Seams, holes, and joints in the air barrier must be sealed. (SWS 4.1303.2c)
4. In cases where HVAC ducts hang below the level of the rigid air barrier and insulation, the ducts must be sealed and insulated and a flexible air barrier provided that is sealed to the rigid air barrier. (SWS 4.1303.2c)
5. When a rigid air barrier is not feasible, a flexible air barrier (e.g. house wrap) shall be installed. Support the air barrier with twine attached at every point it crosses a stud. Attaching twine shall not exceed 12 inch on center. (SWS 4.1303.2c)
6. Installing an air barrier is not required for manufactured housing that sits on a permanent foundation. These floors shall be treated as a conventional floor assembly.

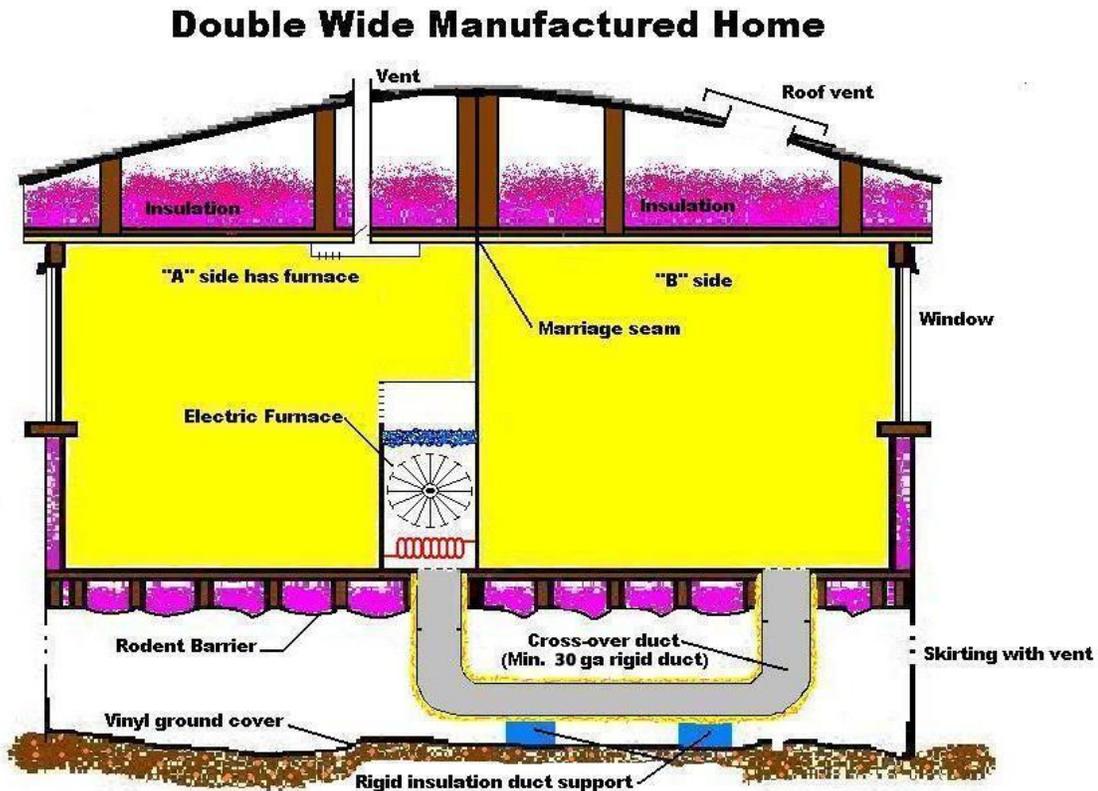
## 16.21 Ventilation

1. When skirted, the entire enclosed underfloor crawlspace area shall be ventilated by openings in the skirting. Provide a net free ventilation area of 1 sq. ft. for each 300-sq. ft. of underfloor area or less, if approved by the agency. (SWS 2.0501.2a)
2. When moisture is not an issue the venting can be 1 square foot of NFA for each 1,500 square feet as long as ground surface is treated with an approved ground cover material and the required openings are placed so as to provide cross ventilation of the space.
3. Vents shall be covered with corrosion-resistant wire mesh, with maximum mesh openings of 1/4 inch. Existing vent openings, which are covered with wire mesh, do not have to be changed if they are serviceable and clean.
4. Occupants must be educated on purpose, operation, and maintenance of vents. (SWS 2.0501.2b)

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## Section 17 : Manufactured Home Heating Ducts

**17.01 General:** Material shall be installed according to the provisions of current Oregon Building Code or other applicable codes and shall meet the requirements of the agency weatherization program. Any other exceptions shall be approved in writing in advance by the agency. Vermin access points must be identified and treated appropriately (e.g., screen rodent access points) CAZ testing shall be performed both pre and post weatherization where combustion appliances are utilized. (SWS 4.1601.4k-l & 4.1601.5e, 2.0101.1a)



**17.02** Inspect, seal, and insulate all heating/cooling ducts in unconditioned areas. All ductwork insulated must have an air barrier (e.g. FSK-Vinyl) installed. (SWS 4.1601.3a &c)

**17.03** Pre-fabricated flexible crossover ducts, if installed, shall have a minimum rating R-8, have an exterior vapor barrier of 1.0 perm or less, and have an interior layer with a spring-steel wire helix bonded with 2 layers of 57-gauge or thicker Mylar™, or equivalent; ensure rodents cannot destroy. (SWS 4.1601.5a)

**17.04** Flame spread on duct insulation: facings on duct insulation shall have a flame spread rating of 50 or less and smoke developed rating that meets code requirements.

**17.05** Seal ductwork as airtight as possible. Ducts must be sealed with UL – 181 mastic before floor insulation is installed. (SWS 4.1601.5b)

Duct sealing must include, but is not limited to the following areas:

1. Joints on the furnace plenum and the furnace plenum connections.
2. Joints and seams on ducts.
3. The boot / interior floor connection and elbow gores.
4. Metal sweeps or rigid insulation board blocks must be installed and sealed where duct runs extend beyond the last register.  
(SWS 2.0107.5a-b)

### **17.06 Reconfigure Return Air System**

1. Eliminate any existing return air systems by closing off and sealing all return air openings that might be located in the floor or ceiling. This shall include the return air opening in the floor of the furnace closet. Openings shall be closed off and sealed with material equivalent to what is existing. (SWS 5.3001.3a)
2. All eliminated return ducts shall be filled with insulation and sealed airtight at the register.
3. Alternate return air opening must be provided to the furnace closet (e.g., replace louvered door or install grilles. (SWS 5.3001.3b)
4. Return air shall then be provided as follows: Provide two square inches of net free area for every 1000 Btu. (i.e. 10 KW furnace you will need 68.2 square inches of NFA; 15 KW you will need to provide 102.3 square inches of NFA).
5. Room pressures must be measured with the furnace fan operating across interior doors that can be closed and have a supply and/or return behind them. Room pressure should not exceed +/- 3 Pascals. If a pressure induced combustion hazard exists, room pressures must be mitigated.  
(SWS 5.30010.3c)
6. The Occupant must be educated on changes, how to operate and maintain the system, and any potential health concerns (e.g., lead, asbestos)  
(SWS 5.3001.3e)

## 17.07 Metal Ducts

1. Wrap all exposed metal ducts, plenums, boots, etc. with a minimum of R-11 insulation. (SWS 4.1601.5a)

Types of insulation and appropriate usage:

- a. Vinyl or FSK faced insulation must be installed on ductwork in unconditioned spaces. (SWS 4.1601.5a, 4.1601.3b-c)
  - b. Using a tape approved by the manufacturer, all seams and connections of the duct insulation in areas of routine human contact must be taped so that no metal or insulation is exposed. (SWS 4.1601.5d)
  - c. Insulation shall be permanently secured with corrosion resistant wire or rot proof twine, installed in a circular fashion and spaced no wider than 18 inch on center. Every effort shall be taken to minimize compression of the insulation. Pattern of twine or wire must be sufficient to securely hold the duct insulation tight to the duct. (SWS 4.1601.5c)
2. Ducts located in crawlspaces shall be supported off the ground and secured to the floor with corrosion resistant wire or galvanized metal hangers. Extruded rigid polystyrene foam (such as Dow Styrofoam™ "blue board") may be used between the duct and the ground. (SWS 3.1602.9c)

## 17.08 Crossover Ducts

1. If the existing crossover metal duct is in good repair, (e.g., mechanically attached and sealed at the connections with mastic, has no sharp bends, holes, stress, or compression, is installed free of standing water, and has an existing level of insulation less than R-8) it shall be insulated to a minimum of R-11 insulation.

Types of insulation and appropriate usage:

- a. Vinyl or FSK faced insulation must be installed on ductwork in unconditioned spaces. (SWS 4.1601.5a, 4.1601.3b-c)
- b. Using a tape approved by the manufacturer, all seams and connections of the duct insulation in areas of routine human contact must be taped so that no metal or insulation is exposed. (SWS 4.1601.5d)
- c. Insulation shall be secured with corrosion resistant wire or rot proof twine, installed in a circular fashion and spaced no wider than 18 inch on center. Every effort shall be taken to minimize compression of the insulation. Twine or wire installed must be sufficient to securely hold the duct insulation in place and tight to the duct. (SWS 4.1601.5c)

2. When installing new crossover ducts, installer shall use rigid metal, with a minimum 26 gauge thickness. The crossover duct shall be screwed together, sealed with UL-181 mastic, insulated to R-11 and suspended or supported off the ground with extruded polystyrene. (SWS 4.1601.5c, 3.1602.9b)
  - a. Avoid excessive compression of the duct/insulation.
  - b. Avoid sharp bends.
  - c. Cut it to the proper length.
  - d. Avoid standing water.

### **17.09 Flex Duct**

1. Where rigid metal duct cannot be installed, Flex-duct may be used. The following criteria must be met when installing flexible duct:
  - a. All flexible ducting installed must have a minimum of R-8. All accessible low R-value flexible ducting must be removed from premises. Duct sizing procedures must be conducted when replacing flex duct.
  - b. Interior liner of the flex-to-metal connection must be fastened with tie bands using a tie band tensioning tool or a mechanical band.
  - c. Exterior liner must be pulled up onto the metal duct as far as possible before securing. The exterior liner must be fastened with tie bands using a tie band tensioning tool.
  - d. All accessible joints, seams, and connections in ductwork must be securely fastened and sealed with UL “181 B-M” compliant mastic (adhesives) or mastic-plus-embedded-fabric systems.
  - e. Vapor barrier of all duct insulation must be taped to the flex duct using the taping system required by the manufacturer of the flex duct.
  - f. Beaded rigid elbow or equivalent must be installed in duct runs whenever change in direction is required.
  - g. All metal fittings including boots, elbows, and take-offs must be insulated separately using an R- 11 duct wrap with vapor retarder. Vapor retarder of all duct insulation must be taped to the flex duct using tape that complies with UL 181B. (SWS 4.1601.4a-j, 3.1602.9b)

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## Section 18 : Air Sealing in Manufactured Homes

**18.01 General:** Material shall be installed according to the provisions of current Oregon Building Code or other applicable codes and shall meet the requirements of the agency weatherization program. Any other exceptions shall be approved in writing in advance by the agency. Presence of lead-based paint in pre-1978 homes must be assumed and when paint is disturbed, appropriate precautions taken unless testing confirms otherwise. (SWS 3.1202.1a, 1b, 3.1201.8a)

A pre-work assessment must be conducted to determine the structural integrity of the home, accessibility, insect infestation, number, type, size and location of penetrations, identify marriage lines, windows and doors to be sealed. (SWS 3.1101.1a, 2a, 3a)

**18.02** Air sealing shall be addressed on all manufactured homes accepted for low-income weatherization.

1. The forced air heating and cooling distribution (duct) system may be required to be sealed, including plenums, boots and registers. All accessible forced air heating or cooling ducts shall be sealed. Supply ducts are a top priority for sealing. See section 17 for specifics.
2. All broken glass or missing panes in prime windows shall be replaced unless cracked glass is not noticeably separated or a hazard. See section 7 for specifics on installation.
3. All large, obvious leaks in the building envelope shall be sealed.
4. All interstitial spaces (house/garage connection, attic/floor penetrations etc.) must be sealed.
5. If floor insulation is being installed, the belly board/Rodent barrier must be sealed. See section 16 for specifics.
6. Water heater closets must be sealed. See section 13 for specifics.

**18.03** Caulking for air sealing purposes shall only be performed on the inside surfaces of the structure except when otherwise stated on the work order. Installers shall follow the manufacturer's instructions for application of caulk.

1. All dirt, loose or peeling paint, caulking and other debris shall be removed from the surface where caulking is to be applied.
2. The depth of caulk shall not be greater than the width of the joint.

3. Filler materials, such as polyurethane foam, backer rod or other suitable materials shall adequately support the caulk when cracks are deeper than 1/2 inch.
4. Single-component polyurethane foam sealants may be used as filler material or as a caulking material provided the manufacturer's installation standards are met.
5. Exterior caulking used as sealant for window glazing replacements shall be one component polyurethane or polysulfide meeting the standards of TT-S-230c.

**18.04** Interior plumbing penetrations shall be sealed.

1. Backing materials, such as polyurethane foam, backer rod or other suitable materials shall adequately support the caulk when cracks are deeper than 1/2 inch. Backing material used must be compatible with sealant.  
(SWS 3.1101.2b)
2. Sealants used must be compatible with the surface on which they are installed.
3. For larger repairs under sinks, like material and/or compatible materials must be used for repairs and is durable enough to last for the life of the structure.  
(SWS 3.1102.2c)

**18.05** Interior walls between conditioned and unconditioned spaces shall have penetrations sealed.

1. Holes and penetrations on the interior surface of exterior walls must be repaired. Like material and/or compatible materials must be used for repairs.  
(SWS 3.1101.2c)
2. When sheetrock repairs are needed, a minimum of one coat of tape and one coat of mud are required.
3. Backing materials, such as polyurethane foam, backer rod or other suitable materials shall adequately support the caulk when cracks are deeper than 1/2 inch. Backing material used must be compatible with sealant.  
(SWS 3.1101.2b)

**18.06** Exterior walls between conditioned space and unconditioned spaces must be sealed as necessary to ensure resistance to outdoor elements.  
(SWS 3.1101.1c)

1. Intentionally ventilated walls must not be sealed at vent locations (e.g., weep holes) (SWS 3.1101.1c)
2. Like material and/or compatible materials must be used for repairs. Materials must be selected to comply with manufactured housing rules and regulations. (SWS 3.1101.1b)
3. Backing materials, such as polyurethane foam, backer rod or other suitable materials shall adequately support the caulk when cracks are deeper than ½". Backing material used must be compatible with sealant. (SWS 3.1101.2b)

**18.07** Marriage lines and marriage walls must be sealed to the following requirements:

1. All accessible holes and penetrations in top and bottom plates of marriage walls must be sealed. (SWS 3.1101.3b)
2. All accessible holes and penetrations at marriage lines must be sealed continuously at end walls, floors, and ceiling. (SWS 3.1101.3c)
3. When caulking is used, backing or infill such as polyurethane foam, backer rod or other suitable materials must be provided at the marriage line and marriage walls on gaps deeper than 1/2 inch and then sealed with an approved caulking. (SWS 3.1101.3b-c)

**18.08** Door weather-stripping shall be one of the following types:

1. Low temperature vinyl or silicone with rigid flange.
2. Interlocking metal.
3. Neoprene.

Note: Self attaching weather-stripping (self-stick or glue type) is prohibited for door weather-stripping unless the door is designed to use such weather-stripping. (e.g. metal manufactured home outswing doors)

**18.09** Weather-stripping Material shall be installed in accordance with the manufacturer's Instructions. (SWS 3.1201.5f)

- 18.10** Surface-mounted weather-stripping material shall be installed to ensure that the weather-stripping sufficiently contacts both surfaces and that the gap is adequately sealed.
- 18.11** Weather-stripping shall be installed in one continuous strip, if possible, along each side of the door or window. The material shall fit tightly at the corners to maintain continuity around the perimeter of the door or window.
- 18.12** All mounting screws, nails, staples or other fastener devices shall be of a non-corrosive material compatible with the weather-stripping material installed.
- 18.13** Weather-stripping material shall be secured with mounting screws, nails, or staples spaced a maximum of 4 inches apart, unless metal or metal-backed weather-stripping is used and supplied with pre-drilled holes. Door weather-stripping shall be secured at the bottom of each side of the weather-strip; the fastener shall be located no higher than 2 inches from the threshold. In no case shall fasteners be over 12 inches apart.
- 18.14** Door bottom weather-stripping may be threshold, interlock or door-bottom mounted vinyl bulb (door shoe). Door bottoms shall not have a surface sweep that rubs against the floor. A fixed door sweep is a door sweep that is permanently attached to the bottom of a door.
- 18.15** Details that reduce air infiltration must be repaired, replaced, sealed, or installed (e.g., plastic gliders, weather-stripping, cranks, latches, locks, knobs, thresholds). (SWS 3.1201.5d)
- 18.16** If water intrusion is an issue, steps must be taken to stop water intrusion (e.g. adjust threshold, caulking or flashing. (SWS 3.1201.5e)
- 18.17** Doors and windows must be adjusted to properly fit the jamb and allow for ease of operation and security. (SWS 3.1201.3b, 3.1201.5g)
- 18.18** All egress windows and doors must be operable. (SWS 3.1201.5c)
- 18.19** Upon completion of the job, all windows and doors that have had weather-stripping installed shall operate properly without undue force and provide a complete air infiltration resistant seal in the most restrictive position. Both door lock and deadbolt lock set shall work without undue force caused by the weather-stripping. The occupants must be notified of changes or repairs made and educated on how to maintain weather-stripping. (SWS 3.1201.5h)



## Appendix A: Minneapolis Blower Door Test



### Blower Door Test

DEVICE		CONFIG	
BD3		OPEN	
- 50.0 ADJ Pa		3,200 CFM@50	
PR/ FL@50		LONG	
MODE		TIME AVG	
↑	DEVICE	UNITS	CONFIG
↓	MODE	CLEAR	TIME AVG
	BASE LINE	START	ENTER
	WRT		WRT

Green Hose to Outside

Red Hose to Fan

Begin with the Frame and Hoses already set-up (with the green hose extended through the door a minimum of 5 feet away from fan) and the fan still covered with the rings.

1. **Connect** Hoses to Manometer
2. Turn Manometer **on**.
3. Press **MODE** Button **2 times**.
4. Press **BASELINE** Button **1 time**.
5. Press **START** Button **1 time**.
6. **Wait** until number is **steady**, then press **ENTER** Button **1 time**.
7. Take cover off of fan.
8. **Slowly** adjust fan speed to reach **50 Pa** on **Channel A**.  
*Note: Channel B will automatically estimate CFM50 once Channel A reaches 15 Pa for the house pressure. Accuracy is +/- 1% when House Pressure reads between 45 and 55 Pa.*
9. As House Pressure nears 50 Pa, you may press the **TIME AVG** Button until it says **LONG**. Record reading when it becomes steady. Press **START** Button once to restart **TIME AVG** if necessary.

**If CFM50 is Less Than 2400**, reduce fan speed to zero and **install Ring A**. Press **CONFIG** Button until it reads **A1**

Compliments of Rees Byars South Carolina Weatherization Program

The blower door is a diagnostic tool designed to measure the airtightness of buildings and to help locate air leakage sites. Building airtightness measurements are used for a variety of purposes including:

1. Documenting the construction airtightness of buildings.
2. Estimating natural infiltration rates in houses.
3. Measuring and documenting the effectiveness of air sealing activities.
4. Measuring duct leakage in forced air distribution systems.

The blower door consists of a powerful, calibrated fan that is temporarily sealed into an exterior doorway. The fan blows air into or out of the building to create a slight pressure difference between inside and the outside. This pressure difference forces air through all holes and penetrations in the exterior envelope by simultaneously measuring the airtightness of the entire building envelope. The tighter the building, e.g. fewer holes, the less air you need from the blower door fan to create a change in building pressure.

The most common blower door test procedures used to assess overall building airtightness are the One Point Test and the Multi Point Test. The One Point Test utilizes a single measurement of fan flow needed to create a 50 Pascal (Pa.) change in building pressure. The One Point Test provides a quick and simple way to measure building airtightness without the need to have a computer to analyze the blower door test data.

The multi-point test procedure involves testing the building over a range of pressures (typically 50 Pascals down to 15 Pascals) and analyzing the data using a blower door test analysis computer program. Making multiple measurements allows some of the errors introduced by fluctuating pressures and operator error to be averaged over several measurements, thus increasing test accuracy. In addition, a multi-point test allows the operator to estimate the leakage area of the building. Leakage area values are used in detailed infiltration models and can be a useful way to express the results of the blower door test.

#### Basic Airtightness Test Results:

CFM 50 is the airflow (in cubic feet per minute, cfm) from the blower door fan needed to create a change in building pressure of 50 Pa. (0.2 inches of water column). A 50 Pa. pressure is roughly equivalent to the pressure generated by a 20 mph wind blowing on the building from all directions. CFM 50 is the most commonly used measure of building airtightness and gives a quick indication of the total air leakage in the building envelope. When conducting a One Point Test at 50 Pa. of building pressure, you are directly measuring CFM 50.

# Appendix B: Building Airtightness Test Form

## TEST DATA FORM

Client Name \_\_\_\_\_  
 Address: \_\_\_\_\_  
 Phone: \_\_\_\_\_

Project# \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Heat Source: Gas / Oil / Electric

# of Occupants \_\_\_\_  
 # of Bedrooms \_\_\_\_  
 # of Rooms \_\_\_\_  
 Volume: \_\_\_\_\_

Physical Mechanical Inspection (i.e. damage, age, general condition)

see additional comments

General House Set-Up Description (i.e. IAQ/Health and Safety Issues)	<b>Spillage:</b> Furnace Yes / No DWH    Yes / No  <b>Roll-Out:</b> Furnace Yes / No DWH    Yes / No  <input type="checkbox"/> see additional comments
--	--

<b>CO AMBIENT (in house)</b>	PRE:	PPM	POST:	PPM
------------------------------	------	-----	-------	-----

<b>CO @ air handler (or nearest supply)</b>	PRE:	PPM	POST:	PPM
---	------	-----	-------	-----

House Room Balancing (pressure in each room, doors closed [Room WRT main body, clockwise])				
	Room	Repair	Pre	Post
1				
2				
3				
4				
5				
6				
7				

Worse Case Depressurization			Draft Testing in worse case		CAZ Testing in worse case	
Equipment	CO		Pre	Post	Pre	Post
	Unit	Pre				
Furnace						
Port 1						
Port 2						
Port 3						
Port 4						
DWH						
Oven			NA	NA	NA	NA
Stove Top RF			NA	NA	NA	NA
Stove Top LF			NA	NA	NA	NA
Stove Top RR			NA	NA	NA	NA
Stove Top LR			NA	NA	NA	NA
Pellet Stove	NA	NA	NA	NA		
Woodstove	NA	NA	NA	NA		

- Worst Case Depressurization Test for Combustion Appliances**
- a) Perform test with all combustion appliances turned on (i.e. furnace, water heater, range, and oven).
  - b) Close and latch all exterior doors and windows.
  - c) Turn on all exhaust appliances including kitchen fans, bath fans, clothes dryers (clean the lint filter first), central vacuum cleaners, and anything else that exhausts air from the house.
  - d) Close interior doors to rooms that do not have exhaust fans and open interior doors to rooms that do. If a bedroom has an attached bathroom with an exhaust fan, leave both the bedroom and bathroom doors open
  - e) Open the door to the combustion appliance zone, whether basement or furnace room.
  - f) Set the pressure gauge so that it is stable, level, plumb, and within two feet of the combustion zone appliance. "Zero" the gauge with the tube disconnected. Extend the tube to outdoors (sheltered location is best). Attach tube to the gauge and record results in client file.
  - g) Repeat the test with the combustion zone door closed to see if depressurization increases. Record in client file.

Other									h) Consult the House Depressurization Limits Chart to determine if there is a potential problem and record in client file.																				
<b>Furnace</b>									<b>House Depressurization Limits (HDL's)</b> <table border="1"> <thead> <tr> <th>Appliance</th> <th>Housing Depressurization Limit</th> </tr> </thead> <tbody> <tr> <td>Atmospheric Draft Water Heater Only</td> <td>-2</td> </tr> <tr> <td>Atmospheric Draft Water Heater common vented with furnace</td> <td>-3</td> </tr> <tr> <td>Gas furnace or boiler, Category I or Category I fan-assisted, open-combustion appliances</td> <td>-5</td> </tr> <tr> <td>Power vented category I appliances</td> <td>-15</td> </tr> <tr> <td>Direct vent -Sealed combustion category IV appliances.</td> <td>-25</td> </tr> <tr> <td>Pellet Stoves</td> <td>-15</td> </tr> <tr> <td>Closed, controlled wood-burning appliances (Woodstoves)</td> <td>-7</td> </tr> <tr> <td>Fireplace (wood or gas) unlined chimneys on exterior wall.</td> <td>-3</td> </tr> <tr> <td>Fireplace (Wood or gas) metal lined insulated or interior chimneys</td> <td>-4</td> </tr> </tbody> </table>	Appliance	Housing Depressurization Limit	Atmospheric Draft Water Heater Only	-2	Atmospheric Draft Water Heater common vented with furnace	-3	Gas furnace or boiler, Category I or Category I fan-assisted, open-combustion appliances	-5	Power vented category I appliances	-15	Direct vent -Sealed combustion category IV appliances.	-25	Pellet Stoves	-15	Closed, controlled wood-burning appliances (Woodstoves)	-7	Fireplace (wood or gas) unlined chimneys on exterior wall.	-3	Fireplace (Wood or gas) metal lined insulated or interior chimneys	-4
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Serial #:		<b>Btu's</b>	<b>KwH</b>																										
Manufacturer:																													
Model:																													
		Pre	Post																										
CO																													
Oxygen																													
CO Air Free																													
Ambient/ Combustion Air Temp																													
Temp Differential																													
Stack Temp																													
Efficiency																													
CO2																													
Excess Air																													
Supply Temp																													
Return Temp																													
Temp Rise																													
Supply Static Pressure																													
Return Static Pressure																													
Total External Static Pressure																													
<b>Water Heater</b>		<b>Model #:</b>		<b>Serial Number:</b>																									
CO		Pre	Post																										
Oxygen																													
CO Air Free																													
Ambient/Combustion Air Temp																													
Temp Differential																													

Stack Temp		
Efficiency		
CO2		
Excess		

<b>Pressure Diagnostic Testing Report</b>					<b>Pre</b>	<b>Post</b>	<b>Ring</b>	
Total CFM 50 IF: house pressure less than 50 Pa, find CRF factor:							<b>A</b> <b>B</b> <b>O</b>	
<b>Record Baseline Pressure =&gt;</b> <b>(Natural)</b>							<b>Location</b>	
<b>Zonal Pressures:</b>								
Zone: ID Duct Zones			Pre	Post	<b>Notes:</b>			
1. Attic	WRT House							
2. Crawlspace	WRT House							
3. Garage (Attached)	WRT House							
4. Bsmt (Door Closed)	WRT House							
5. Other	WRT House							
6. Other	WRT House							
<b>Pressure Pan Test</b> (clockwise from front door, house WRT duct.)								
Location		<b>Pre</b>	<b>Mid</b>	<b>Post</b>	Location	<b>Pre</b>	<b>Mid</b>	<b>Post</b>
1					7			
2					8			
3					9			
4					10			
5					11			
6					12			
Air Handler "ON"/ House Pressure: Main body WRT Outside (all interior doors open)								
Duct Blaster: Total Leakage CFM								
Duct Blast: Total duct leakage to outside								
Duct leakage not to exceed 10 percent CFM50 x floor area (Sq.Ft.) if existing. New construction must be 6 percent OR be reduced by 50 percent by comparing leakage to the outside before and after sealing of heated floor area.								
Primary problems (concerns)								
Proposal for improvement/mediation/retro-fit (if any):								

Pre-Inspection Signature of Qualified Diagnostic Technician: \_\_\_\_\_

Date: \_\_\_\_\_

Post-Inspection Signature of Qualified Diagnostic Technician: \_\_\_\_\_

Date: \_\_\_\_\_



## **Appendix C: Attic Bypass Sealing**

Installer shall seal all attic bypasses before insulating. Use appropriate material depending on size of the opening. These materials may include:

1. High temperature caulk,
2. Silicone caulk, urethane caulk, and silicon latex caulk,
3. Polyethylene rod (also called backer rod in different thickness),
4. Expanding foam (polyurethane one part expanding and non-expanding, including high temperature and two-part urethane foam),
5. Gypsum board, sheet metal, plywood, extruded polystyrene (XPS),
6. Rigid insulation board,
7. Densely packed cellulose.

The following is a list of suggested areas for attic bypasses:

1. Top plates of interior wall partitions (where sheetrock/plaster attaches to framing),
2. Housing of exhaust fans and recessed lights (where housing and ceiling join),
3. Soil vent stacks and plumbing vents (where they penetrate the ceiling),
4. Around duct work (where HVAC ducts penetrate the ceiling),
5. Electrical light boxes (where a box and ceiling join), Electrical wiring (where wires or conduit penetrate the ceiling),
6. Other building materials which pierce the finished ceiling. These areas shall be caulked or foamed depending on the size (diameter) of the opening.
7. Open top plates of interior partition walls (where no top plate exists),
8. Exterior walls (balloon framed construction or missing top plates),
9. Clothes chutes and dumb waiters (if they penetrate the ceiling, seal at that point), and any other larger openings that terminate through the ceiling.

The following pages offer step by step procedures for sealing various types of bypasses.

**Standard Chase Capping (SWS 3.1001.2b)**

**Specification(s):**

Entire opening will be spanned with rigid material. Material will be cut to fit and fastened as required.



Clear area of insulation and debris



Apply sealant around the opening



Trim patching material to size and place over sealant

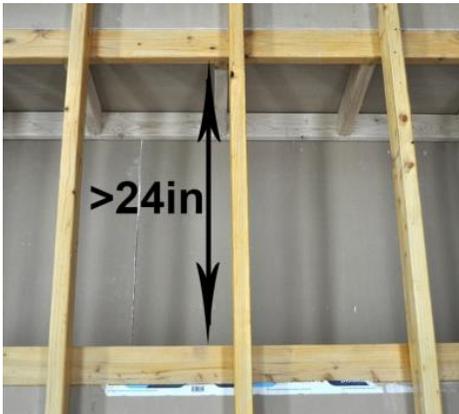


Fasten patching material with screws

**Large (Wider than 24") chase capping require additional support.**  
(SWS 3.1001.2d, 3.1001.3c, 3.1003.1c, 3.1003.2c, 3.1003.3c, 3.1003.4c)

**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)



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



When supporting form above, apply adhesive between drywall and bracing



Bracing can be screwed to drywall before capping the chase



Ensure new bracing is secure by using screws or nails to fasten to the joist



Once the chase is capped, the joint along the framed must be sealed

**Chase Caps require sealing**

(SWS 3.1001.2e, 3.1001.3d, 3.1003.1d, 3.1003.2d, 3.1003.3d, 3.1003.4d)

**Specification(s):**

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



After capping, chases must be sealed



Sealant is used to fill in all cracks and gaps along edges of the cap



Thoroughly sealed cap

Framing adjacent to the cap must be sealed.  
(SWS 3.1001.2f, 3.1001.3e, 3.1003.1e, 3.1003.2e, 3.1003.3e, 3.1003.4e)

**Specification(s):**

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



Sealant must be used to fill in all cracks and gaps along the edges of the chase cap



Sealant must be extended along adjacent framing

**Walls Open to Attic—Balloon Framing and Double Walls (SWS 3.1001.3b)**

**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



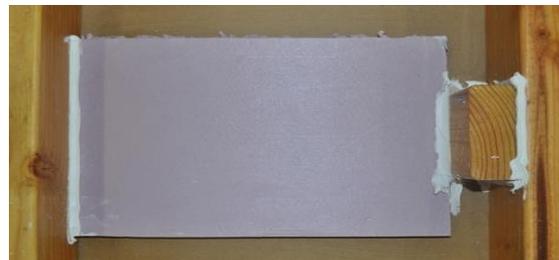
Option 1: Dense pack cavities with cellulose or fiberglass



Option 2: Bridge cavities with spray foam



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



Option 3, Step 2: Cap with XPS or sheetrock and seal exposed joints.

Walls Open to Attic—Balloon Framing and Double Walls (SWS 3.1001.3d)

**Specification(s):**

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

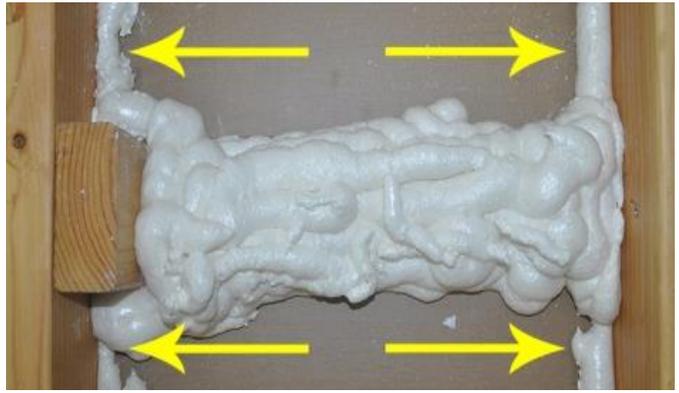
**Objective(s):**

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

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



For rigid material applications, extend sealant along all seams and adjacent framing.



Extend Sealant or SPF along joist to seal all gaps. Extend SPF or sealant along joist and adjacent framing to ensure thorough sealant.

**Dropped Ceiling below Original Ceiling—Old Ceiling Intact or Repairable**  
(SWS 3.1003.1b)

**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

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

Exterior wall below openings will be dense packed

Interior wall openings open to the top attic will be bridged and sealed with SPF

**Objective(s):**

Prevent air leakage from dropped ceiling to attic.



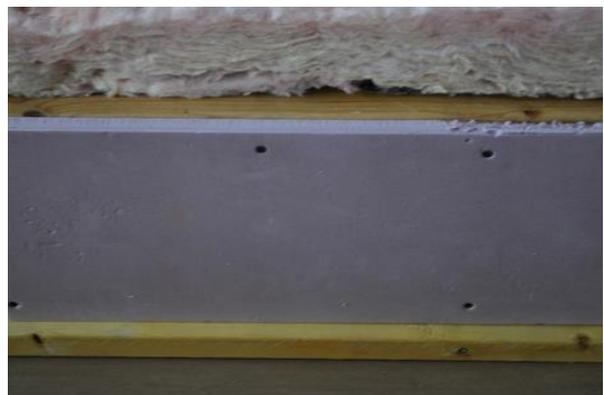
Prepare work area by removing existing insulation and debris from top ceiling



Step 1: Run a bead of sealant around the damaged areas.



Step 2: Cover openings with rigid material. XPS or sheetrock may be used. Secure in place using screws.



Step 3: 1- If there are open exterior wall cavities below the original ceiling, seal with rigid materials along the face of stud cavities.



Step 3: 2- Drill and dense pack any exterior wall cavities to ensure a complete thermal barrier. These can be accessed from the top plate as shown or from the sidewalls, either exterior or from inside the dropped ceiling cavity, if accessible.



Step 4: Any interior wall cavities that are open at the top ceiling level must be sealed off. One option is to wrap Batts in poly bags and seal with SFP.

**Above Closets and Tubs (SWS 3.1003.3b)**

**Specification(s):**

Option 1: 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

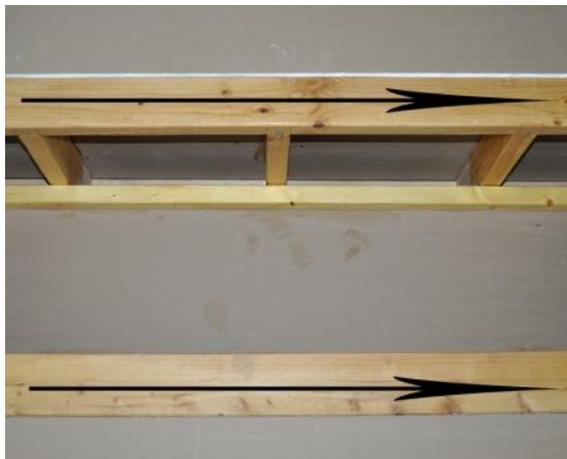
Option 2: Side of stud bays will be sealed with rigid material from bottom of dropped ceiling to top-plate

OR

Option 3: Wall below openings will be dense packed

OR

Option 4: Wall below openings will be bridged and sealed with SPF



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



Option 1, Step 2: Cover soffit with rigid material such as drywall. Secure in place using screws.



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



Option 2: Cover the face of the stud bay with rigid material such as XPS or plywood.



Option3: Dense pack cavity through fastened wood cap.



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

**Dropped Soffits** (SWS 3.1003.6b, 6c, 6d)

**Specification(s):**

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

**Objective(s):**

Provide continuous air barrier across soffit openings

Bring dropped soffits inside: Seal top of soffit



Seal top of soffit: Before- Wall cavities are open to the attic allowing for air leakage into the attic.



After: Top of soffit capped with rigid material, secured and thoroughly sealed.

Leave dropped soffits outside: Seal stud bays



Clear work area of insulation and debris.



Option 1: Span each stud bay with rigid material at the level of the stud bay, seal thoroughly.



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



Option 3: Stud bay will be covered with rigid material, fastened and sealed.

## Appendix D: Lead Paint Notification Form

### **SAMPLE PRE-RENOVATION FORM**

This sample form may be used by renovation firms to document compliance with the Federal pre-renovation education and renovation, repair, and painting regulations.

#### **Occupant Confirmation**

Pamphlet Receipt

- I have received a copy of the lead hazard information pamphlet informing me of the potential risk of the lead hazard exposure from renovation activity to be performed in my dwelling unit. I received this pamphlet before the work began.

---

Printed Name of Owner-occupant

---

Signature of Owner-occupant

Signature Date

#### **Renovator's Self Certification Option (for tenant-occupied dwellings only)**

Instructions to Renovator: If the lead hazard information pamphlet was delivered but a tenant signature was not obtainable, you may check the appropriate box below.

- Declined** – I certify that I have made a good faith effort to deliver the lead hazard information pamphlet to the rental dwelling unit listed below at the date and time indicated and that the occupant declined to sign the confirmation of receipt. I further certify that I have left a copy of the pamphlet at the unit with the occupant.
- Unavailable for signature** – I certify that I have made a good faith effort to deliver the lead hazard information pamphlet to the rental dwelling unit listed below and that the occupant was unavailable to sign the confirmation of receipt. I further certify that I have left a copy of the pamphlet at the unit by sliding it under the door or by (fill in how pamphlet was left).

---

Printed Name of Person Certifying Delivery

Attempted Delivery Date

---

Signature of Person Certifying Lead Pamphlet Delivery

---

---

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Unit Address

**Note Regarding Mailing Option** — As an alternative to delivery in person, you may mail the lead hazard information pamphlet to the owner and/or tenant. Pamphlet must be mailed at least seven days before renovation. Mailing must be documented by a certificate of mailing from the post office.



## Appendix E: Set-Up for Blowing High Density Wall Insulation

1. The recommended filler tube is 1-1/4 inch inside diameter with 1/8 inch walls in 10 foot lengths. The installer should purchase a summer tube (for use above freezing) that is #220 hard industrial vinyl and a winter tube (for use below freezing) that is #224 soft industrial vinyl. The installer should also purchase a 1-1/8 inch inside diameter tube, made of the same material and the same length, for filling smaller cavities when the larger tube will not operate correctly.



2. The preferred insulation blower hose would be as follows: a 3-inch hose off the blower for 50 feet to 100 feet; add a 2-1/2 inch tubing for each additional 10 feet to 50 feet. From there a 2 inch hose for about 10 feet. Connectors should be metal reducers and be clamped or duct taped in place to allow for a quicker disconnect when the hoses clog up. The end of the filler tube should be cut at a 45-degree angle (filed smooth) to allow for easier access into the cavity.



Magnehelic Gauge

3. The blower, at the port, should measure 80" of water column (W.C.).



## Appendix F: Accessing Wall Cavities from Exterior for Insulation Installation

LRRP/LSW requirements apply to all pre-1978 homes. Lead paint must be assumed unless testing proves otherwise.

1. **Wood lap siding:** use a thin edge pry bar to slide between laps and gently lift out nails. Start in the middle of the piece if the ends of the siding bind. Nails can be driven through the siding by using a nail punch. Remove nails from two courses and drop out the lower board. Tack the board on the house or put it in a safe place nearby. Replace any broken pieces with primed new siding that matches the original siding. Re-nail to code with galvanized or aluminum 6p-7p siding nails.



2. **Wood shakes and shingles:** score the paint vertically on each shake to be removed. Pry loose and pull side to side and down to remove the shake or shingle. If the first method doesn't work, score the top of the shake or shingle at a 45-degree angle at the point where it meets the underlayment course. Drill the hole through the underlayment and the underlayment shake/shingle. Replace by tapping up the shake/shingle or by applying a small bead of caulking at the 45-degree cut and installing in the original position. Face nail the shake/shingle to code with a required size of shake nail or a 3p-5p galvanized box nail, whichever is appropriate.



3. **Aluminum, steel or vinyl siding:** start at either a corner or a seam, if it has continuous corner ports. Pull open the J-lock at the bottom of the piece above the one, which is to be removed. Use a zip tool or flat bar to start the process. Clothesline rope with a knot at one end can be pulled along inside the lock-seam to open the siding without bending it. As an alternative, a flat bar can be pulled along the lock-seam, but shall avoid damaging the siding with the flat bar. The channel trim around doors, windows, and other protrusions shall be bent, in most cases to completely remove the siding. Vinyl is easy to handle but should not be done when it is cold.

Oxidized aluminum siding is more difficult to remove. Remove nails from the top of the siding, push it down, the J-lock should open and the siding will come off. Tack it or store it near so that it will be protected. When reinstalling the siding, snap it back on the bottom and put nails through the same hole to center it where it was before the removal. Use the zip tool to re-hook the J-lock.



4. **Cement/asbestos shakes:** cement asbestos shakes are either face nailed or blind nailed. For face nailed applications, pull the nails out with pliers or end cutters. Be careful not to drop the shingle. For blind nailed applications, pull the nails from two runs. Remove the blind nails from the top of the lower shake with a pry or flat bar. Do not force it. If house is back-plastered or full of fire stops, it may be easier to insulate the wall and patch the plaster or gypsum board from the inside. Never drill or saw asbestos shakes.



5. **Stucco:** break a 2 inch to 2-9/16 inch hole through the stucco with a rock pick, air chisel or rotary hammer. Pry open the wire lath, drill and fill as usual. In most cases a very sharp, carbide tooth drill bit will cut through the stucco, lath, and sheathing. Patch the holes with stucco patching material. Be sure to match the stucco as close to the original texture as possible.



6. **Masonite lap siding & LP Board:** Do not attempt to pry it off. Drive the nail head through the siding with a nail punch. Be careful not to damage the siding during the removal process. Reinstall the siding with 4p - 6p galvanized siding nails. Use outdoor spackling in the old nail holes while reinstalling the siding.
7. **Asphalt shingles:** remove nails by various methods from three runs and then remove the shingles like siding. Fold the tar paper back and drill through the sheathing. Reinstall the shingles in the original position with 5p - 8p galvanized box nails. Insulating walls with this type of siding is not recommended when the weather is hot.



8. Drill through the sheathing with a low speed drill (400 - 600 rpm) fitted with a self-feed or plantar bit. The drill bit size, under most conditions shall be 2 - 2 1/2". If possible, angle the hole up and down in the direction the tube will have to be inserted. Installer is responsible for not damaging the structural integrity of the sheathing while drilling the holes.



## **Appendix G: Accessing Wall Cavities From Inside the House for Wall Insulation**

Inside surface drilling is the fastest method if the house is empty and/or receiving other rehabilitation measures. This system is also used as a backup for other methods in trouble spots and can stand alone as a method. LSW/LRRP protocols must be followed on pre-1978 homes unless testing proves no lead paint is present.

1. Have the occupant or homeowner move all furniture and stored items 4 feet back from the outside wall. Prepare the occupant or homeowner for intrusion of workers and major dust. Have occupant or homeowner sign an acceptance for having this work performed. The installer is responsible for any damage that occurs as the result of blowing wall insulation.
2. Mask contents of house with polyethylene drop cloths. Extra care should be taken on electrical equipment such as stereos, home computers, TV's, VCR's, etc.
3. Drill at least 2 inch to 2-9/16 inch holes in the plaster or sheet rock with a carbide-tipped hole saw, planar bit, or other drill bit of installer's choice. Don't cut into the same lath on both sides of the stud. This prevents cracks from showing up later. Use the two-hole procedure for normal cavities.
4. Fill cavities as normal. Unless probing proves it unnecessary, the exterior run of the partition wall should also be filled to prevent bypass. Use trickle feed for cavities too narrow to tube fill, e.g. back-plaster.
5. After filling the cavities, install a piece of unfaced fiberglass in the hole prior to installing the patching material.
6. Patch the base coat as soon as possible. Use mixtures such as Structolite™ and Durabond™ 30-60 mixed stiff enough not to sag. Never put on too much. Apply as many coats as needed to completely fill the hole; (topcoat with joint compound or spackle, if needed). Other patching products are acceptable, as long as the finished product matches the existing surface.
7. Roll up the poly, clean up any spilled cellulose, and other debris.



## **Appendix H: Moisture Control**

Moisture problems can occur any time of year. Traditionally recognized indoor moisture problems are dampness, odors, mold, and stains on surfaces, condensation on windows and pipes whose temperature is below the dew point temperature of the indoor air. These conditions not only have an adverse effect on building components but also occupant's health. Steps are to be taken to eliminate such conditions when they exist.

Interview the occupant or homeowner and perform a careful visual inspection to determine the extent of the problem. All parts of the residence should be inspected including inside the house, in the attic, crawlspace or basement and exterior surfaces. The optimum level is between 30 percent to 50 percent relative humidity. However, when preventing mold and mildew, the suggested indoor relative humidity levels are below 50 percent. Levels of approximately 30 percent may be necessary to minimize window condensation, especially in cold weather.

Oregon code for local ventilation fans (kitchen and bathroom) exhaust fans are 80 cfm for each bathroom supplied on an intermittent basis when a bathroom is used. 150 cfm for kitchen exhaust on an intermittent basis when required.

Bathroom exhaust fan airflow rates measured in cubic feet per minute (cfm) are often well below 50 cfm, in large part because of the way they are ducted to the outside. The Energy Conservatory Exhaust Fan Flow Meter or a flow hood can be used to measure airflow.

Whole building ventilation that is operated continuously or intermittently is required as calculated under the ASHRAE 62.2 ventilation protocol. Educating the client on the importance of using these fans is vital to an overall moisture control strategy.

The first step in moisture control is to reduce or eliminate unneeded sources. Examples include: fixing gutters, downspouts and foundation drains, venting a clothes dryer outdoors, covering containers while cooking, removing excessive amounts of firewood stored indoors (a large moisture source), reducing the number of indoor plants, emptying fish tanks. The exposed ground in a crawlspace can be a major source of indoor moisture due to evaporation from its surface. When accessible, it is important to cover any exposed crawlspace ground and install foundation vents.

Exhaust fan ducting shall be extended through the roof when vented into an attic. Adequate venting is required to remove excess moisture. If the fan cfm is too low, it often can be increased up to 40 percent simply by replacing the three-inch diameter ducting with four-inch ducting. Replacing flex duct with rigid metal duct also will increase the flow rate up to 40 percent. Successful moisture control strategy includes energy education, including but not limited to: regular use of kitchen and bathroom exhaust fans for 10-20 minutes longer than bathroom/kitchen use.



## Appendix I: Mold & Mildew Protocol

### Mold Protocol Checklist

Dwelling Inspection: Moisture and Mold Checklist

Item for Inspection	Y / N Explanation, if necessary
Are the air filters clean?	_____
Is there any sign of water damage?	_____
Are there any unique or objectionable odors (mold mildew)?	_____
Is there any blockage/obstruction to the supply or exhaust fans?	_____
Do the bathrooms lack exhaust fans?	_____
Are there any signs of mold or mildew growth?	_____
Do the combustion appliances lack flues?	_____
Do any drains lack traps?	_____

Confirmation of Receipt of Mold and Moisture Pamphlet (Required if any inspection items are marked "yes")  
I have received a copy of the pamphlet, *A Brief Guide to Mold, Moisture, and Your Home*, informing me of the potential risks, clean-up and prevention of mold problems in my dwelling unit. I received this pamphlet before the work began.

\_\_\_\_\_  
Printed name of recipient Date

\_\_\_\_\_  
Signature

#### Self-Certification Option (for tenant-occupied dwellings only)

*If the mold pamphlet was delivered but a tenant signature was not obtainable, you may check the appropriate box below.*

**Refusal to sign**—I certify that I have made a good faith effort to deliver the pamphlet, *A Brief Guide to Mold, Moisture, and Your Home*, to the rental dwelling unit listed below at the date and time indicated and that the occupant refused to sign the confirmation of receipt. I further certify that I have left a copy of the pamphlet at the unit with the occupant.

**Unavailable for signature** – I certify that I have made a good faith effort to deliver the pamphlet, *A Brief Guide to Mold, Moisture, and Your Home*, to the rental dwelling unit listed below at the date and time indicated and that the occupant was unavailable to sign the confirmation of receipt I further certify that I have left a copy of the pamphlet at the unit by sliding it under the door.

\_\_\_\_\_  
**Print name of person certifying mold pamphlet** **Attempted delivery date and time delivery**

\_\_\_\_\_  
**Signature of person certifying mold pamphlet delivery**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Unit Address

Note Regarding Mailing Option – As an alternative to delivery in person, you may mail the mold pamphlet to the owner and/or tenant. Pamphlet must be mailed at least seven days before renovation. (Document the date with a certificate of mailing from the post office.)

The Oregon Low-Income Weatherization Assistance Program does not encompass mold remediation. DOE funds are not to be used to test, abate, remediate, purchase insurance or alleviate existing mold conditions identified during the assessment, the work performance period or the quality control inspection. Where multiple funding sources are used, the performance of any of the aforementioned activities must be expensed to a non-DOE funding source. However, DOE funds may be used to correct energy-related conditions and/or to assure the immediate health of workers and occupants.

Weatherization of a home and air sealing in particular could potentially increase the risk of moisture and mold in a home, thereby causing structural damage and/or health risk to the inhabitants. As well, existing mold could pose a health risk to both the occupants and the weatherization crew.

### **Moisture Assessment**

#### **All homes should be checked for previous or existing moisture problems:**

1. Mold in homes arises from conditions of excess moisture. During initial inspection, field coordinators are to assess the homes with special attention to the following signs:
  - A. Evidence of condensation on windows and walls indicated by stains or mold.
  - B. Standing water, sumps, open wells, dirt floors, water stains, etc. in basements. Also, check to see if firewood is stored in the basement and whether laundry is hung there to dry during the winter months;
  - C. Leaking supply or waste pipes;
  - D. Attic roof sheathing shows signs of mold or mildew.
2. Identification of existing or potential moisture problems shall be documented in the occupant or homeowner file.
3. If existing moisture problems are found, no air sealing should be done unless the source of the moisture can be substantially reduced or effective mechanical ventilation can be added to cost-effectively remove the moisture. In some cases, air sealing must be done in order to reduce the source of the moisture (i.e. sealing off crawlspace from the house, or sealing attic leakage to eliminate condensation on the roof deck).
4. Because air tightening may cause an increase in relative humidity, energy education should include information about moisture problems and possible solutions.
5. In the course of weatherization, any low-cost measures that help reduce the humidity levels in the house should be installed. Examples of these activities are venting dryers, venting existing bath or kitchen exhaust fans or installing ground cover on dirt floors.

## **Repair moisture problems that might:**

1. Result in health problems for the occupant.
2. Damage the structure over the short- or long-term, or
3. Diminish the effectiveness of the weatherization measures, must be done before the weatherization job is completed.
4. Moisture problems can be reduced or eliminated by controlling the source of the moisture. This can involve:
  - A. Install 6 mil ground cover on a crawlspace floor;
  - B. Vent dryers to the outside of the building;
  - C. Seal the foundation;
  - D. Provide positive drainage away from foundation;
  - E. Repair the roof, flashing, gutter, and downspout;
  - F. Educate the occupant about the sources of moisture that they are able to control.
5. Moisture problems can be reduced or eliminated by ventilating areas where excessive moisture is produced, such as bathrooms and kitchens. This should include installation of a high quality exhaust fan in the subject area and informing the occupant of the related moisture issues and the proper operation and use of the fan.

## **Dryer Vents**

1. All dryers must be vented to the outdoors and terminated with an operable dryer vent hood. Outdoors does not include unconditioned spaces such as attics and crawlspaces that are ventilated with the outdoors (SWS 6.6005.1a)
2. The operable dryer vent hood must include a backdraft damper. The outlet must be sealed to prevent water and air intrusion. (SWS 6.6005.3c)
3. Dryer vent ductwork must be smooth surfaced, rigid sheet metal, supported at each connection in the crawlspace and vented to daylight utilizing the shortest run possible. Use of elbows should be limited to the least possible number to ensure unobstructed venting. Plastic venting is not allowed. (SWS 6.6005.1a)
4. All joints must be sealed using UL – 181 tape (metal tape). (SWS 6.0005.1a)
5. Connections to the dryer and the dryer vent hood must be secured with a clamp as well as sealed with UL 181 tape. (SWS 6.6005.1a)

6. Flexible metal vent pipe may be used between the dryer and the hard pipe connection if it does not exceed three feet in length. The connection between the flexible metal and rigid metal vent pipe must be secured with a clamp as well as sealed with UL 181 tape. (SWS 6.0005.1a)
7. Dryer vent pipe must not be installed with sheet metal screws or other intrusive fasteners that will collect lint. (SWS 6.6005.1a)
8. Whenever possible, the dryer vent must be installed with a downward slope to the outside to allow for condensation drainage.
9. Dryer vents exceeding 35 foot in duct equivalent length must have a dryer booster fan installed.  
(SWS 6.6005.1a)
10. Occupant will be instructed to keep lint filter and termination fitting clean. If applicable, occupant will be instructed to keep dryer booster fan clean, if present. (SWS 6.6005.1e)

### **Mold Protocols: Mold Assessment/Clean-up**

All homes should be checked for mold during the initial inspection. If a mold condition is discovered during the initial inspection of the home that cannot be adequately addressed by the weatherization crew, then the dwelling unit should be referred to the appropriate public or non-profit agency for remedial action. As well, occupants must be notified and informed of the presence of mold in their homes, and are to be given a copy of the pamphlet *A Brief Guide to Mold, Moisture and Your Home*. If the moldy area is less than 10 square feet (about 3 feet by 3 feet) then the job can most likely be handled by the weatherization crew.

1. Professional should be contacted when:
  - A. The mold covers more than 10 square feet.
  - B. There is evidence of extensive water damage.
  - C. It is suspect that the heating/ventilation/air conditioning (HVAC) system may be contaminated, i.e. there is mold near the intake of the system. The HVAC is not to be run, as it could spread mold throughout the house.
  - D. The water and/or mold damage was caused by sewage or other contaminated water.
  - E. There is a health concern.
2. Instances when the moldy area is less than 10 square feet, the following steps may be taken:
  - A. Eliminate or repair all moisture problems using the aforementioned moisture protocols.

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#### **Appendix I: Mold & Mildew Protocol**

- B. Scrub mold off hard surfaces with detergent and water and dry completely.
- C. Absorbent materials, such as ceiling tiles and carpet, may have to be thrown away when they become moldy. Mold can grow on or fill in the empty spaces and crevices of porous materials, so the mold may be difficult or impossible to remove completely.
- D. Avoid exposing yourself or others to mold.
- E. Do not paint or caulk moldy surfaces. Clean up the mold and dry the surfaces before painting. Paint applied to the moldy surfaces is likely to peel.
- F. When unsure about how to clean an item, or if the item is expensive or of sentimental value, a specialist should be consulted.
- G. Avoid breathing in mold or mold spores. In order to limit your exposure to airborne mold, N-95 respirators are recommended when working in moldy areas.
- H. Wear gloves. Long gloves that extend to the middle of the forearm are recommended.
- I. Wear goggles. Goggles that do not have ventilation holes are recommended.
- J. Revisit the site(s) shortly after clean-up to make sure that it shows signs of water damage or mold growth.



## Appendix J: ASHRAE 62.2 Reference Tables

Table 4.1a

Floor Area SQFT	Bedrooms				
	1	2	3	4	5
<500	30	38	45	53	60
501-1000	45	53	60	68	75
1001-1500	60	68	75	83	90
1501-2000	75	83	90	98	105
2001-2500	90	98	105	113	120
2501-3000	105	113	120	128	135
3001-3500	120	128	135	143	150
3501-4000	135	143	150	158	165
4001-4500	150	158	165	173	180
4501-5000	165	173	180	188	195

**TABLE 5.3 Prescriptive Duct Sizing**

Duct Type	Flex Duct								Smooth Duct								
	50 (25)	80 (40)	100 (50)	125 (65)	150 (75)	200 (100)	250 (125)	300 (150)	50 (25)	80 (40)	100 (50)	125 (65)	150 (75)	200 (100)	250 (125)	300 (150)	
Fan Airflow Rating, cfm @ 0.25 in. of water (L/s @ 62.5 Pa)																	
Diameter <sup>a</sup> , in. (mm)	Maximum Length <sup>b,c,d</sup> , ft (m)																
3 (75)	×	×	×	×	×	×	×	×	×	5 (2)	×	×	×	×	×	×	×
4 (100)	56 (17)	4 (1)	×	×	×	×	×	×	×	114 (35)	31 (9)	10 (3)	×	×	×	×	×
5 (125)	NL	81 (25)	42 (9)	16 (5)	2 (0.6)	×	×	×	×	NL	152 (46)	91 (28)	51 (16)	28 (9)	4 (1)	×	×
6 (150)	NL	NL	158 (48)	91 (28)	55 (17)	18 (5)	1 (0.3)	×	×	NL	NL	NL	168 (51)	112 (34)	53 (16)	25 (8)	9 (3)
7 (175)	NL	NL	NL	NL	161 (49)	78 (24)	40 (12)	19 (6)	×	NL	NL	NL	NL	NL	148 (45)	88 (27)	54 (16)
8 (200) and above	NL	NL	NL	NL	NL	189 (58)	111 (34)	69 (21)	×	NL	NL	NL	NL	NL	NL	198 (60)	133 (41)

- a. For noncircular ducts, calculate the diameter as four times the cross-sectional area divided by the perimeter.  
b. This table assumes no elbows. Deduct 15 ft (5 m) of allowable duct length for each elbow.  
c. NL = no limit on duct length of this size.  
d. × = not allowed; any length of duct of this size with assumed turns and fitting will exceed the rated pressure drop.





## Appendix K: Minimum Acceptable Draft Pressures

The action level (AL) will be when the appliance tested does not meet minimum acceptable draft pressure, listed below, with the combustion appliance zone (CAZ) set up set up in the worst case depressurization test. If the minimum acceptable draft requirements are not met, then action shall be taken to achieve the minimum required draft pressure with the CAZ set up in worst case.

Minimum acceptable draft pressures are the combustion appliance (CA) vent/flue with reference to (WRT) to the combustion appliance zone (CAZ) with the CAZ under worst case. Field calculations of minimum draft can be calculated using the following formula: outside temperature minus 100 divided by 20 (outside temp. -100 / 20)

	<b>Outside Temperature</b>	<b>Draft</b>	
1.	Below 20° F	Draft	-5.0 pa
2.	20° F	Draft	-4.0 pa
3.	22° F	Draft	-3.9 pa
4.	24° F	Draft	-3.8 pa
5.	26° F	Draft	-3.7 pa
6.	28° F	Draft	-3.6 pa
7.	30° F	Draft	-3.5 pa
8.	32° F	Draft	-3.4 pa
9.	34° F	Draft	-3.3 pa
10.	36° F	Draft	-3.2 pa
11.	38° F	Draft	-3.1 pa
12.	40° F	Draft	-3.0 pa
13.	42° F	Draft	-2.9 pa
14.	44° F	Draft	-2.8 pa
15.	46° F	Draft	-2.7 pa
16.	48° F	Draft	-2.6 pa
17.	50° F	Draft	-2.5 pa
18.	52° F	Draft	-2.4 pa
19.	54° F	Draft	-2.3 pa
20.	56° F	Draft	-2.2 pa
21.	58° F	Draft	-2.1 pa
22.	60° F	Draft	-2.0 pa
23.	62° F	Draft	-1.9 pa
24.	64° F	Draft	-1.8 pa
25.	66° F	Draft	-1.7 pa
26.	68° F	Draft	-1.6 pa
27.	70° F	Draft	-1.5 pa
28.	72° F	Draft	-1.4 pa
29.	74° F	Draft	-1.3 pa
30.	76° F	Draft	-1.2 pa
31.	78° F	Draft	-1.1 pa
32.	80° F	Draft	-1.0 pa



## Appendix L: Worst Case Depressurization Test of Combustion Appliances

With this test procedure, the goal is to measure worst-case depressurization in all combustion rooms with natural draft appliances and fireplaces. This measurement gives us an indication of the likelihood of exhausts and air handler fans causing the combustion appliances to back draft and spill. The procedures below measure worst case depressurization under three separate operating conditions; running exhaust fans only, running exhaust and air handler fans, and running the air handler fan only. These tests are very sensitive to wind effects, and on windy days, it can be very difficult to get accurate results.

**Initial Preparation:** Close all exterior windows and doors and be sure furnace and water heater and other vented combustion appliances are off. Open all interior doors. Set up a digital gauge to measure the pressure difference between the combustion appliance zone (CAZ) with reference to (WRT) outside, record the base pressure.

### COMBUSTION APPLIANCE ZONE AND WORST CASE DRAFT TESTING

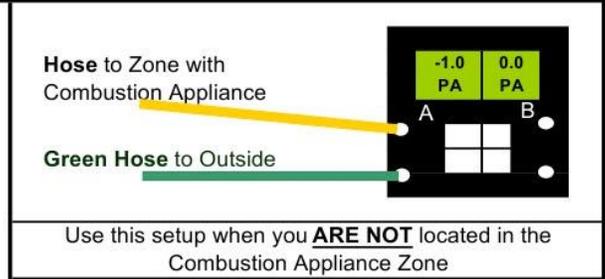
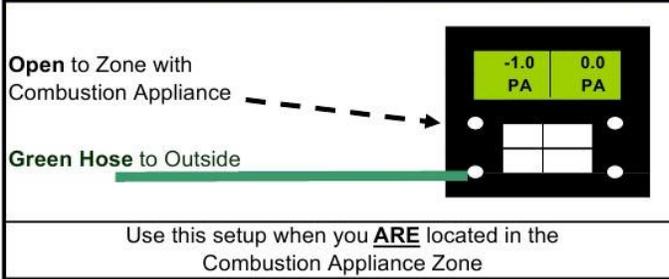
## You are in CAZ

House Should be in Winter Mode with Blower Door Fan Covered  
 Setup Hoses to Measure:  
CAZ with reference to Outside on Channel A and  
Vent with reference to CAZ on Channel B (based on your location)

1. Connect Hoses to Manometer
2. Turn Manometer on.
3. Press **BASELINE** Button 1 time.
4. Press **START** Button 1 time.
5. Wait until number is **steady**, then press **ENTER** Button 1 time.
6. Follow Procedure to Determine Worst Case Depressurization on the back of this sheet
7. **Recreate Worst Case Depressurization and Perform Worst Case Draft Test on each Appliance starting with the smallest BTU.**
8. You may press the **TIME AVG** Button until it says **LONG**. Record reading when it becomes steady. Press **START** Button once to restart **TIME AVG** as necessary.

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## Combustion Appliance Zone (CAZ) Testing



- a. VISUALLY INSPECT VENTING (of each Combustion Appliance)
- b. TURN OFF ALL COMBUSTION APPLIANCES.
- c. CLOSE ALL OPERABLE VENTS AND DAMPERS.
- d. CHECK DRYER VENT and LINT FILTER
- e. CHECK FURNACE FILTER (clean or replace if needed)
- f. OPEN ALL INTERIOR DOORS.

**NOTE: IF BLOWER DOOR IS SET UP, BE SURE FAN IS COVERED.**

1. Setup Manometer and Pressure hoses to measure CAZ (WRT) Outdoors
2. Take Baseline Pressure & Subtract it Manually from All Readings if Manometer doesn't have baseline function. \_\_\_\_\_ Pa
3. Turn on all exhaust fans (do not turn on whole-house fans).
4. Close all interior doors to rooms that do not have exhaust fans.

	Appliance 1		Appliance 2		Appliance 3	
	Pre	Post	Pre	Post	Pre	Post
5. Open door, if present, between CAZ and Main Body of house. Record reading.	Pa	Pa	Pa	Pa	Pa	Pa
6. Close door between CAZ and Main Body of house. Record reading. <i>(If no door, skip to Step number 8)</i>	Pa	Pa	Pa	Pa	Pa	Pa
7. Turn on Furnace Blower. Check position of interior doors with smoke puffer for worst case. If the smoke blows towards the CAZ, leave the door shut.	Pa	Pa	Pa	Pa	Pa	Pa
8. Open door between CAZ and Main Body of house. Record reading. <i>(If no door, skip step)</i>	Pa	Pa	Pa	Pa	Pa	Pa

9. Recreate Worst Case Conditions for each CAZ (Complete this and following steps on each Heating Inspection form)
10. Perform Worst Case Draft and Combustion Tests for each appliance under this worst case condition

- \* If Ambient CO gets above 35 ppm, discontinue testing and remove CAZ from worst case conditions.
- \* There should be no spillage after 1 minute of Worst Case and draft should be established after 5 minutes

Dominant Duct Leakage Test (Main Body WRT outdoors) Baseline _____ PA Dominant Duct _____ PA															
Pressure in Individual Rooms (Room WRT Main body)															
Room	Bef	Int	PR	Aft	Room	Bef	Int	PR	Aft	Room	Bef	Int	PR	Aft	
1.					4.					7.					
2.					5.					8.					
3.					6.					9.					

### **Exhaust Fans Only:**

Turn on all exhaust fans found in the survey (for dryer, clean out lint filter before turning on). Determine the worst case position of interior doors with the smoke test below:

Smoke Test: While standing in the main body of the house, squirt smoke under each door containing an exhaust fan (except the CAZ currently being tested). If the smoke goes into the room, open the door. If the smoke comes back into the main body of the house, keep the door closed. Now squirt smoke under the CAZ door (while continuing to stand in the main body). If smoke goes into the CAZ, leave the CAZ door shut. If smoke comes back into the main body of the house, open the door.

Measure the depressurization of the CAZ with respect to (WRT) outside caused by the exhaust fans. Depressurization should not exceed the appropriate House Depressurization Limits (HDL) limits listed in Appendix Q. If it is windy, it is often necessary to turn fans off and on several times to obtain good pressure readings.

Fireplace Zones: For fireplace zones, repeat the same procedure and measure and record depressurization of fireplace zone WRT outside from exhaust fan operation. Depressurization should not exceed the appropriate HDL limits listed.

#### 1. Air Handler and Exhaust Fans:

With exhaust fans continuing to run, turn on the air handler fan (note: air handler fan only when possible) and close supply registers in combustion appliance room. For both CAZ and fireplace zone tests, re-determine worst case position of all interior doors with the smoke test described above. If cooling is available, be sure air handler fan is running at high speed. Repeat worst case depressurization measurements.

#### 2. Air Handler Fan Only:

Turn off all exhaust fans and leave air handler operating (if cooling is available, be sure air handler is running at high speed). For both CAZ and fireplace zone tests, re-determine worst case position of all interior doors with the smoke test described above. Repeat worst case depressurization measurements.

\*\*\*If HDL limits are exceeded for any of the worst case depressurization tests above, pressure relief is needed. Pressure relief could include duct system repair, undercutting of doors, installation of transfer grilles, eliminating or reducing exhaust fan capacity, or instructing homeowner on safe exhaust fan operation. If negative pressures in the combustion appliance zone (or basement) are a function of return leaks in that area, check for leaks in the return ductwork, plenum, filter access door and air handler cabinet. Pay particular attention to panned under floor joist (used as returns) as they typically have many leaks.



## **Appendix M: House Depressurization Limits (HDL)**

<b>House Depressurization Limits (HDL)</b>	
<b>Appliance Type</b>	<b>House Depressurization Limit ( Pascals)</b>
Atmospherically drafting appliance	-3
Fireplace	-4
Gas furnace or boiler, Category I or Category I fan-assisted, open-combustion appliances	-5
Power vented category I appliances	-15
Direct vent -Sealed combustion category IV appliances.	-25
Direct vent solid fuel appliance with outside combustion air. (Pellet stoves, EPA inserts, etc)	-15
Controlled atmospheric wood-burning appliances (Woodstoves)	-7



## **Appendix N: Spillage & Draft Testing**

(Natural draft and induced draft appliances)

This test identifies actual spillage of combustion byproducts into the living space under worst case depressurization conditions:

1. With house set up in worst case depressurization mode (as specified in Appendix L) fire up each combustion appliance.
2. If appliances are common vented, conduct test on smallest input appliance first, then test with both appliances running.
3. When burner lights, check for flame rollout (stand away from burner).
4. Check for spillage (using chemical smoke) at the end of the spillage test period. For natural draft appliances, spillage is tested at the draft diverter. When an induced draft heating system is vented in common with a natural draft water heater, spillage is checked at the water heater draft diverter. For a single induced draft appliance, spillage is checked at the base of the chimney liner or flue, typically using the drip tee at the bottom of the liner.
5. Spillage of combustion products for more than 2 minutes warm vent/5 minutes cold vent is unsatisfactory.
  - A. If spillage occurs, beyond the spillage test period, remove the negative pressure in combustion room by turning off fans and/or opening an exterior window or door.
  - B. Re-check for spillage. If spillage stops, there is a pressure induced spillage problem. If spillage continues, check flue and chimney for obstructions, and check compatibility of appliance BTU input with chimney size.
  - C. If the problem is a blocked flue or chimney, or inadequately sized flue or chimney, consult a professional heating installer.
  - D. If the problem is pressure induced, provide pressure relief. Re-check for spillage following attempt to provide pressure relief. If spillage continues, contact a professional heating installer.

### **Draft Test**

This test measures flue draft pressure in the venting systems of all natural and induced draft combustion appliances under worst case depressurization (**not to be done for sealed combustion appliances**).

1. Drill a small hole in the vent pipe approximately 2 feet downstream (chimney side) of the draft diverter or inducer fan. Appliances with a barometric draft damper must have draft measured on the appliance side of the barometric control rather than the chimney side. Insert a static probe/tap.
2. Measure draft pressure (vent WRT combustion room) with digital pressure gauge.
3. Compare measured draft with minimum draft pressures in Appendix K.

If measured draft is below the minimum draft pressures in Appendix K, check for flue or chimney obstructions, disconnected vents, open chimney cleanout doors, etc. Also remove sources

depressurization (e.g. turn off exhaust fans) and test again to determine if CAZ depressurization is contributing to poor draft.

## **Appendix O: Carbon Monoxide (CO) Test**

Carbon Monoxide Test: This test measures carbon monoxide levels in all operating combustion appliances.

### **CO testing for vented furnaces, room heaters and water heaters**

After 5 minutes of appliance operation, measure the CO level in the flue products of all vented combustion appliances.

Natural draft furnaces or water heaters - CO must be measured before appliance draft diverter or barometric damper. In multi-burner furnaces, each exhaust port must be tested separately. On water heaters, check CO levels on each side of the baffle.

Induced draft furnaces – CO can be measured in the hole drilled in the vent.

Sealed combustion condensing furnaces – CO must be measured at the termination of the vent. **NOT** drill the PVC vent pipe.

Sealed combustion manufactured home furnaces – CO must be measured at the termination of the vent. Do **NOT** drill concentric vent pipe.

Sealed combustion condensing furnaces that have condensate line ports that are not utilized and are above the water table may be used to test combustion gasses including CO.

When the vent termination requires testing from the roof or other hazardous location, if agency policy prohibits or conditions jeopardize the safety of the technician, CO testing at the vent termination may be omitted. Ambient CO must be measured and documented. Conditions and reasons for omitting testing must be documented. The appliance must be run through a heat cycle and observed for proper operation.

**CO levels must be below 100 ppm as measured or 200 ppm air free for combustion appliances other than gas ovens.**

### **CO testing for Gas Ranges**

#### **Oven testing**

1. Set the oven to bake on the highest temperature
2. Let the oven warm up for 5 minutes
3. Measure CO levels at the exhaust port



### **Range Tops**

Since all range top burners will produce CO at various levels depending on the duties they are performing, no action level is specified in these specs. However, the following are recommended whenever a gas cook top is present in the home:

1. If the burners do not ignite properly or do not burn properly, have the appliance serviced to assure proper operation.
2. If there is no exhaust fan present in the room that the cook top is located, install a new kitchen exhaust fan vented to the outside. If not possible to install a fan, documentation as to why a fan cannot be installed must be in the file.

### **Action levels**

1. When CO levels are below 200 ppm as measured or 800 ppm air free in the oven; NO further action is necessary
2. When CO levels are above 200 ppm as measured or 800 ppm air free in the oven; have the appliance serviced to bring CO down to acceptable levels.
3. If after servicing, the appliance CO production cannot be brought down to within acceptable limits, confirm that there is an existing exhaust fan in operating properly and vented to the outside. If no fan is present, install a new kitchen exhaust fan vented to the outside. If not possible to install a fan, documentation as to why a fan cannot be installed must be in the file.
4. All kitchen fans installed must have a minimum 150 cfm rating for range hoods or provide 5ACH if ceiling mount while on the highest speed and be rated at no more than 3 Sones.

### **Measure ambient CO level in house**

1. Start your digital CO tester outside before entering the house. Note outside levels of CO.
2. Measure the ambient CO level in all living areas of the house. Be sure to measure ambient CO levels in kitchens and in combustion appliance rooms.
3. Subtract the outside CO levels from levels noted inside the home.
4. Investigate any ambient CO level above 2 ppm.
5. Continue to monitor ambient CO during combustion testing. Discontinue testing if ambient CO levels exceed 35 ppm. (SWS 2.0103.1b)

### **Maximum ambient CO concentration guidelines**

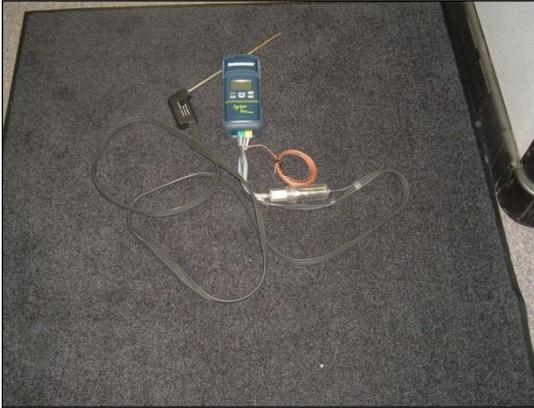
9 ppm for 8-hour exposure: Investigate and mitigate source.

35 ppm for 1-hour exposure: Discontinue testing, ventilate the home and investigate and mitigate source.

Ambient CO concentrations at or above these levels require immediate remedial action.

## CO Alarms

At least one operable CO alarm meeting UL 2034 requirements shall be installed on each floor or any home with any type of combustion appliance. The alarms must be installed according to the manufacturers' instructions and to ASHRAE requirements. A CO release form signed by the client must be included in the client file.



Combustion Analyzer (CO measuring equipment)



CO Alarm



## **Appendix P: Carbon Monoxide Alarm Release Form**

Staff of the agency will install and test the carbon monoxide alarm.

To: \_\_\_\_\_ Date: \_\_\_\_\_

Address: \_\_\_\_\_

### **Release (Please read before signing)**

I understand that \_\_\_\_\_

Agency makes no warranties of any kind regarding the following items, or their installation, at the above listed address:

Carbon Monoxide Alarm. (This alarm will detect carbon monoxide (CO) only for the next five (5) years from this date: \_\_\_\_\_)

In consideration for the provision and installation of this carbon monoxide alarm at the above-described address for me, I agree to release and hold harmless its officers, agents, and employees from all claims, demands, and damages of any kind, to persons or property, resulting from the failure of the carbon monoxide alarm.

Further, by signing this document, I also certify that the carbon monoxide alarm is in working condition when installed.

\_\_\_\_\_  
Signature of owner/occupant

Date: \_\_\_\_\_



## **Appendix Q: Room To Room Pressure Test Procedure**

The room pressures test measures the pressure differences created in rooms when the air handler is operating while the interior doors are closed. Pressurization can drive moisture into building components (walls, ceilings, floors, etc.) creating durability and health issues. Depressurization can draw in outside air (containing water vapor, soil gases, mold spores, residual pesticides and herbicides, etc.) or depressurize combustion appliance zones (CAZs). Pressure imbalances increase a home's infiltration/exfiltration rate creating efficiency and comfort issues.

Significant pressures may be generated in individual rooms because often they have supply registers but no return registers. When interior doors are shut, these rooms become pressurized and the main body becomes depressurized. The amount of pressure change generated depends on how much supply air is delivered to the room, how well connected the room is to the outside, and how well connected the room is to the rest of the house. Basements and furnace closets can also be depressurized from air leaks in the return plenum, the filter access, the air handler cabinet, or the return ducts, which can affect the ability of combustion appliances to draft properly (causing dangerous back drafting or flame roll out) and also pull in moisture and soil gases into the home.

**Test Procedure:** The room pressures test measures the pressure difference between each room in the house with reference to (WRT) the outside of the home while the air handler is operating:

1. Close all windows, exterior and interior doors, open supply registers, and ensure that a clean air filter is installed in the air handler.
2. Turn the air handler on (to high speed if more than one speed).
3. Use a digital manometer pressure gauge (DG-700, DG-3, etc.) and two air hoses. One will be run to the outside and one to test room pressures. The hose to the outside will be connected to the reference tap and the interior hose will be connected to the input tap.
4. While standing in the main body of the home, place the hose from the input tap under each interior door into the room being careful not to put the end of the hose into an air stream.
5. Record the test results for each room on the diagnostic form, including the basement and air handler closet (pressure in the room WRT the outside).
6. Consider pressure balancing for rooms pressurized or depressurized by more than three Pascals. If a back draft situation or any combustion zones exceeds HDL's, room pressure mitigation is required.

Prior to performing pressure balancing complete all shell air sealing measures, perform duct sealing and ensure that all flex ducts are properly installed. Prior to initiating pressure balancing, must clearly discuss with the homeowner the pressure balancing problems, plans and options.

**Pressure Balancing Methods:** Improve the return air pathway (to equalize air pressure) between the main body of the house and the bedrooms.

1. Install bypass grills in doors or walls (if possible, offset the grills for privacy).
2. Install jumper ducts through the attic or floor (at least one size bigger than the supply duct to that room).
3. Undercut bedroom and hallway doors.
4. Reduce air handler's fan speed (if doing so will not greatly affect the furnaces temperature rise).
5. Install a return duct to rooms that are pressurized (preferably, off of the plenum).
6. Install a supply duct to rooms that are depressurized (preferably, off of the plenum).
7. Always post-test the home.

Note: Room pressure testing is required on all homes with forced air heating systems.

## **Appendix R: Dominant Duct Leakage Test**

This test measures whole house pressurization or depressurization caused by duct leakage to the outside during operation of the air handler fan. A pressure change due to duct leakage can cause safety, durability, comfort, and efficiency problems. In some cases, duct repair can cause a problem or make it worse. Diagnosing which side of the system is causing a dominant pressure helps determine a safe and effective treatment strategy.

1. Be sure all exterior doors and windows in the building are closed. Replace all HVAC filters (be sure they are clean). Open all interior doors and check that all exhaust fans, including clothes dryer, and air handler fan are off. Set up a gauge to measure pressure. Run a hose from the reference tap to the outside.
2. Turn on the air handler fan and record the change in building pressure indicated on the gauge.
3. Greater leakage on the return side of the duct system will typically cause the building to become pressurized since the return ductwork is drawing outside air into the ductwork. In this case, there will be a positive reading on pressure gauge. The size of the pressure change will depend on both the amount of imbalanced duct leakage and the tightness of the building being tested.
4. Greater leakage on the supply side of the system will typically cause the building to become depressurized since the supply ductwork is exhausting building air to the outside, just like an exhaust fan. In this case, there will be a negative reading on pressure gauge. The size of the pressure change will depend on both the amount of imbalanced duct leakage and the tightness of the building being tested.
5. If there is no change in building pressure, this means that there is either equal supply and return leakage to the outside, no leaks to the outside, or the building itself is too leaky for the duct leakage to create a measurable pressure change.

If the furnace fan pressurizes the house, there is air being drawn into the house through the return side of the distribution system. If the house is depressurized, look for leaks in the supply air system. Keep in mind that sometimes wall or floor cavities are used as part of the supply or return system. Even without any pressurization or depressurization of the entire house, there could still be leaks between the ductwork and the outside. In cold climates, pressurizing a house to even one Pascal could lead to moisture problems caused by forcing warm, moist air into the walls and attic. In warm humid climates, depressurization by one Pascal can also cause severe moisture problems. If there are natural draft combustion appliances, or if radon is a problem, depressurizing a house by 1 Pascal may also be a problem.



## Appendix S: Pressure Pan Testing

An alternative method for diagnosing duct leaks with the blower door can be performed with a gasketed cake pan with pressure taps attached (pressure pan). This method involves placing the pressure pan completely over each register and taking a quick pressure reading while the blower door is depressurizing or pressurizing the house by 50 Pascals. For very large registers, taping over the register and inserting a hose through a small hole in the paper will do just as well. This simple pressure measurement provides a quick and reliable indication of whether significant duct leaks are located near the register being tested. In addition, it can be used to tell crews if they have done a good job of duct sealing.

For example, if the duct being tested is completely sealed, the pressure pan will read zero pressure between the register and the room. If the duct leading to the register is completely disconnected in an attic or crawlspace, the measured pressure will be close to the zonal pressure of the area containing the ductwork. Testing to date has shown that well sealed ductwork (new construction and retrofit) will almost always register less than 1 Pascal using the pressure pan method.

### Zonal Testing

### Pressure Pan Testing

**Directions for Baseline (Zonal and Pressure Pan):**

1. Turn Manometer on.
2. Press **BASELINE** Button 1 time.
3. Press **START** Button 1 time.
4. Wait until number is steady, then press **ENTER** Button 1 time.
5. **Slowly** adjust fan speed to reach **50 Pa** on **Channel A**.
6. **Connect** Zone or Pressure Pan Hose to **Channel B & Read Pa**

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## **Appendix T: Duct Testing**

### **Total Duct Leakage Test**

Instructions for the Minneapolis Duct Blaster and DG-700-Digital Gauge or follow instructions from other manufacturer's equipment:

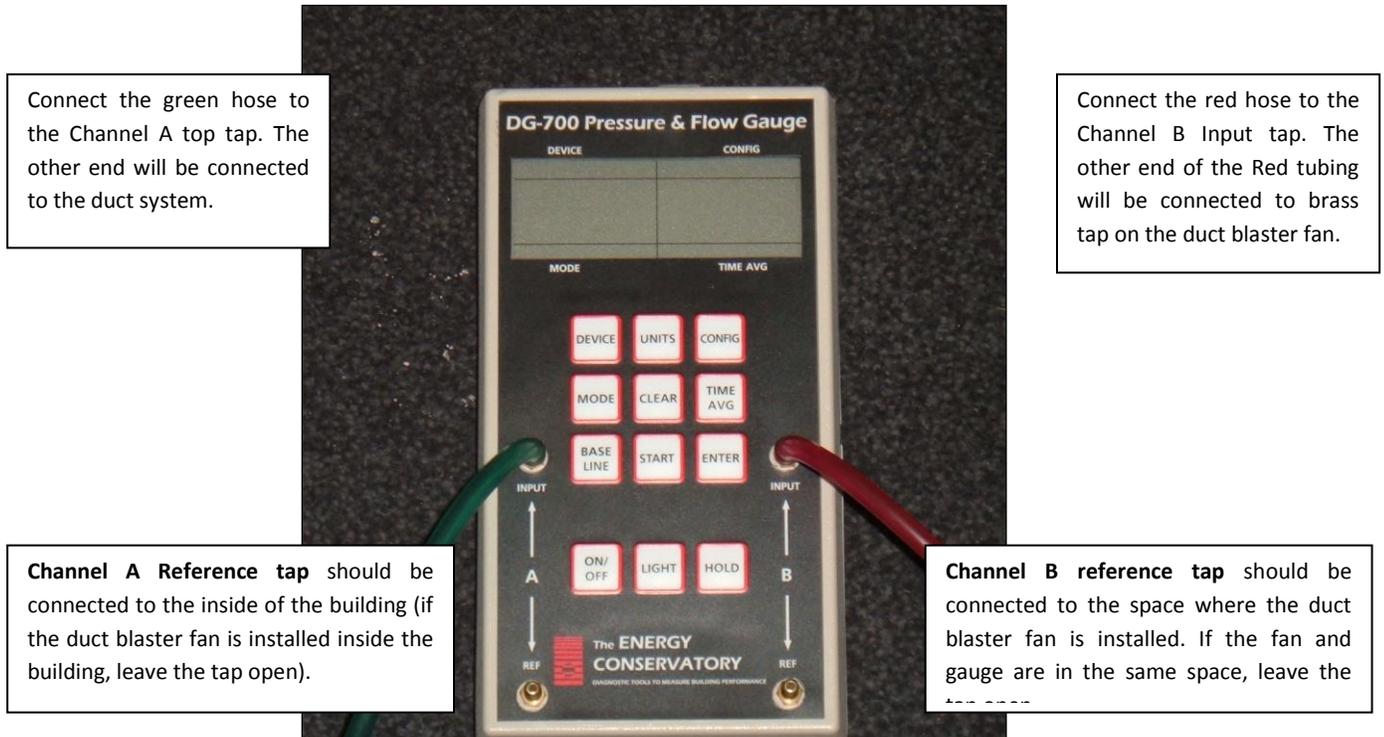
1. Connect the duct blaster to the duct system
  - A. Choose a location to install the duct blaster fan. In single, double or triple returned systems, the largest and closest return to the air handler is usually the best choice. Note: In multi-return systems (a return in every room), installing at the air handler cabinet is often best.
  - B. Remove any remote filters from the chosen return and then connect the black square transition piece to the return using temporary tape. Completely seal the remaining open area of the return with tape.
  - C. Pull the duct blaster fan and flex duct out of the carrying case. Disconnect the flex duct from the fan and insert the foam flow conditioner into the round transition piece. Connect the flex duct along with one of the flow rings to the inlet side of the fan. (i.e. the side without the metal guard) using the round transition piece and connect trim. When installing the flow ring, sandwich it between the round transition piece and the fan inlet flange. Use the flow ring which you think best matches the needed fan flow. Connect the open end of the flex duct to the square transition piece using the Velcro™ strap on the flex duct
  - D. Connect the fan speed controller to the fan and plug it into a 110V outlet.

Fan Configuration	Flow Range (CFM)
Ring 1	800-225
Ring 2	300-90
Ring 3	125-20

2. Prepare the duct system and house for the test.
  - A. Adjust the HVAC system controls so that the air handler does not turn on during the test.
  - B. Temporarily seal off all remaining supply and return registers, and combustion or ventilation air inlets that are connected to the duct system. Use Duct Mask™ temporary register sealing material provided with your duct blaster, or use painters tape and paper.
  - C. Turn off any exhaust fans, vented dryers, and room air conditioners.
  - D. Remove all central filters (i.e. in air handler or return plenum).
  - E. Open a door or window between the house and outside to prevent changes in house pressure when the duct blaster is running.
  - F. If the duct blaster is installed in an attic, garage, or crawlspace open vents or access panels or doors from these spaces to the outside.
3. Connect hoses to DG-700 Pressure Gauge
  - A. Select a location to measure duct pressure. The best location for measuring duct pressure is often in the supply trunk line or plenum. Drill a small hole (1/4inch to 3/8 inch OD) into the duct to allow a static pressure probe to be installed. Install the static pressure probe with the end of the probe pointing into the air flow from the duct blaster fan. If the duct system is reasonably airtight (e.g. less than 200 cfm 50 of leakage), duct pressures can be measured at any supply register by inserting a hose through the temporary register seal.
  - B. Use channel A to measure duct pressure, and channel B to measure duct blaster fan flow. Connect hoses to the DG-700 as shown in the diagram.

## Gauge Hose Connections for Pressurization Testing

The duct blaster comes with 2 pieces of color coded hosing: 1) a 15 foot length of green hosing for measuring duct system pressure, and 2) a 10 foot length of red hosing to measure fan pressure and flow. Connect the hoses to the gauge(s) as shown below:



## Conducting a Total Leakage Pressurization Test

The total leakage pressurization test is used to measure the duct leakage rate in the entire duct system (including leaks in the air handler cabinet), when the duct system is subjected to a uniform test pressure. The total leakage pressurization test measures both duct leakage to the outside of the building (e.g. leaks to attics, crawlspaces, garages and other zones that are open to the outside), and duct leakage to the inside of the building. This test procedure requires use of a duct blaster system only. (Test pressure of 50 Pa.) with duct blaster fan installed at air handler. The airflow through the duct blaster fan required to pressurize the duct system to the test pressure is the measured total duct leakage rate.

The following instructions assume you have set up the duct blaster system for a pressurization test as outlined above. Information on how to conduct a total leakage depressurization test (i.e. pulling air out of the duct system) located below.

## Conducting the Test

1. Turn on the gauge by pressing the on/off button.
2. Press the mode button two times to put the gauge into the PR/FL mode. In this mode, Channel A is used to measure duct system pressure while Channel B is used to display estimated total duct leakage at a test pressure of 50 Pascals.
3. Check (and adjust if necessary) the selected test device (i.e. fan) and configuration (i.e. flow ring) shown in the upper part of the gauge display to match the fan and flow ring being used in the test. For example, the device icon for the Series B duct blaster fan is DB B, and the configuration icon for Ring 2 is B2. Press the device button to change the selected fan. Press the configuration button to change the selected flow ring.
4. Turn on the duct blaster fan by slowly turning the fan controller clockwise. As the fan speed increases the duct pressure displayed on Channel A should also increase. Continue to increase the fan speed until the duct pressurization shown on Channel A is at 50 Pascals.
5. Channel B will now display the One Point 50 Pascal total duct leakage estimate. Record this number. If the leakage estimate is fluctuating more than desired, try changing the time averaging setting on the gauge by pressing the time average button and choosing the 5 or 10 second or long-term averaging period.
6. If low appears on Channel B in the PR/FL mode the DG 700 cannot calculate the leakage estimate. If possible, you should change the flow ring and test configuration to match the flow rate being measured (i.e. install a flow ring or a smaller ring).

Note: If you change the flow ring on the fan, be sure and change the configuration setting on the gauge to match the installed ring.

## Gauge Settings for DG-300

1. Turn the mode switch to the fan “select” position and choose the duct blaster fan and current flow ring configuration. To change the fan type to the Minneapolis Duct Blaster fan, toggle the “select” switch up twice.  
-8-0 This indicates that you have chosen the Minneapolis Duct Blaster fan, and that the fan is in the “open” inlet configuration (e.g. no flow rings installed).

To change the flow ring configuration for the Duct Blaster fan, toggle the “select” switch down

-8-1 Duct Blaster with ring 1 installed

-8-2 Duct Blaster with ring 2 installed

-8-3 Duct Blaster with ring 3 installed

2. Put the range switch in the “high range” position (200 Pa), and turn the channel knob to “A”.
3. Turn the mode switch to “pressure”.

## Conducting the Test

1. With the channel knob set to “A”, turn on the duct blaster fan by slowly turning the fan controller clockwise. As the fan speed increases, duct pressure indicated on Channel A should also increase. Increase fan speed until the duct system is pressurized to the specified test pressure (typically 50 Pascals).

2. While leaving the fan speed unchanged from, turn the channel knob to “B”, and turn the mode switch to “flow”.
3. The gauge will now display the total duct leakage reading in cubic feet per minute (cfm). If the cfm leakage reading displayed on the gauge is blinking, either install a flow ring, or install the next smaller flow ring. If you change flow rings, be sure to use the fan select feature to update the gauge with the new flow ring installed before conducting the leakage test. Note: Never monitor Channel A (duct pressure) with the mode switch in the “flow” position.

## Leakage to the Outside Test Procedure

One-Point 50 Pascal Leakage to Outside Pressurization Test (blowing air into the duct system)  
Using the Minneapolis Duct Blaster™ DG-700 Digital Gauge and Minneapolis Blower Door™

1. Connect the Duct Blaster fan to the duct system.
  - A. Choose a location to install the Duct Blaster fan. In single, double or triple returned systems, the largest and closest return to the air handler is usually the best choice. Note: In multi-return systems (a return in every room), installing at the air handler cabinet is often best.
  - B. Remove any remote filters from the chosen return and then connect the black square transition piece to the return using temporary tape.
  - C. Completely seal the remaining open area of the return with tape.
  - D. Pull the Duct Blaster fan and flex duct out of the carrying case. Connect the flex duct to the *exhaust side* of the fan (i.e. the side with the metal guard) using the round transition piece and connect trim. Connect the open end of the flex duct to the square transition piece using the Velcro™ strap on the flex duct.
  - E. Connect the fan speed controller to the fan and plug it into a 110V outlet.
  - F. Install the Flow Ring which you think best matches the needed fan flow.
2. Prepare the duct system and house for the Test.
  - A. Adjust the HVAC system controls so that the air handler does not turn on during the test.
  - B. Temporarily seal off all remaining supply and return registers, and combustion or ventilation air inlets which are connected to the duct system. Use Tape temporary register sealing material provided with your Duct Blaster, or use painters tape and paper.
  - C. Turn off any exhaust fans, vented dryers, and room air conditioners.
  - D. Remove all central filters (i.e. in air handler or return plenum).
  - E. If the Duct Blaster is installed in an attic, garage or crawlspace - open vents or access panels or doors from these spaces to the outside.
  - F. Install the Blower Door system (including a gauge to measure building pressure with reference to outside) in a centrally located exterior door. Set up the Blower Door fan to pressurize the house (blowing air into the house). Because we will not be measuring air flow through
  - G. the Blower Door fan during the test, the fan can be set up in pressurization test mode, or it can be set up in the standard depressurization test mode with the fan direction switch reversed to blow air into the house.
  - H. Prepare the house for a Blower Door test as described in the Blower Door manual.
3. Connect tubing to the Duct Blaster Gauge.
  - A. Select a location to measure duct pressure.
  - B. Install the static pressure probe with the end of the probe pointing into the air flow from the Duct Blaster fan.
  - C. Connect tubing to the DG-700 from the static pressure probe to the input tap on the “A” side and form the duct blaster to the “B” side input tap.

4. Conducting the Test.
  - A. Turn on the Blower Door fan and pressurize the house to 50 Pascals.
  - B. Turn on the Duct Blaster DG-700 gauge by pressing the ON/OFF button.
  - C. Press the MODE button once to put the gauge into the PR/ FL Mode. In this Mode, Channel A is used to measure duct system pressure while Channel B is used to display air flow through the Duct Blaster fan.
  - D. Check (and adjust if necessary) the selected test Device (i.e. fan) and Configuration (i.e. Flow Ring) shown in the upper part of the gauge display to match the fan and Flow Ring being used in the test. For example, the Device icon for the Series B Duct Blaster fan is DB B, and the Configuration icon for Ring 2 is B2. Press the DEVICE button to change the selected fan. Press the CONFIG button to change the selected Flow Ring.
  - E. With the Blower Door fan continuing to run, turn on the Duct Blaster fan by slowly turning the fan controller clockwise. Continue to increase the fan speed until the pressure between the duct system and the house (Channel A on the Duct Blaster DG-700) reads zero.
  - F. Now re-check the Blower Door building pressure gauge and if necessary, re-adjust the Blower Door fan speed to maintain a building pressure of 50 Pascals.
  - G. Re-check the Duct Blaster DG-700 and if necessary, re-adjust the Duct Blaster fan until Channel A reads zero. Channel B on the Duct Blaster DG-700 will now display the CFM50 leakage to the outside estimate. Record this number. If the leakage estimate is fluctuating more than desired, try changing the Time Averaging setting on the gauge by pressing the TIME AVG button.
5. "LO" appearing on Channel B. Whenever "LO" appears on Channel B in the PR/ FL Mode, the DG-700 cannot display a reliable fan flow reading. The message "LO" appears on Channel B under the following two conditions:
  - A. "LO" is continuously displayed when there is negligible air flow through the test device.
  - B. "LO" alternates with a flow reading when the air flow reading through the device is unreliable (i.e. you are trying to measure a flow outside of the calibrated range of the test device in its current configuration). If possible, you should change the test device configuration to match the flow rate being measured (e.g. install a Flow Ring or a smaller Flow Ring).

Note: If you change the Flow Ring on the fan, be sure to change the Configuration setting on the gauge to match the installed Ring.

**DIAGNOSTIC DATA FORM**

Client Name: \_\_\_\_\_  
 Address: \_\_\_\_\_  
 Phone: \_\_\_\_\_

Project #: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Heat Source: Gas / Oil / Electric

# of Occupants: \_\_\_\_\_  
 # of Bedrooms: \_\_\_\_\_  
 # of Rooms: \_\_\_\_\_

<b>BLOWER DOOR TESTING</b>				PRE	MID	POST
Record Baseline Pressure _____ →						
Fan Configuration:				Ring: O/A/B	Ring: O/A/B	Ring: O/A/B
Total CFM 50 (If pressure less than 50 Pa, ref CRF factor):						
Fan Pressure (Pa):						
<b>Zone Pressures: ID Duct Zones</b>			PRE	POST	Blower Door Location: Front Dr/Back Dr/Side Dr	
1. Attic	WRT House/Outside				<b>NOTES:</b>  (ie – windy conditions, taped fireplace, etc.)	
2. Crawl Space	WRT House/Outside					
3. Garage (attached)	WRT House/Outside					
4. Basement (door closed)	WRT House/Outside					
5. MH Exterior Water Heater Cabinet (combustion)	WRT House/Outside					
6. Other	WRT House/Outside					
7. Other	WRT House/Outside					
<b>Room Pressure Balancing:</b> (pressure in each room doors closed [room WRT outside]). +/- 3 Pa						
Location	Repair	PRE	POST	Location	Repair	PRE POST
1.				8.		
2.				9.		
3.				10.		
4.				11.		
5.				12.		
6.				13.		
7.				14.		

<b>DUCT LEAKAGE TESTING</b>				PRE	MID	POST	Test Location:
Dominant Duct Leakage (Pa):							Pressure Tap Location:
Ring Configuration: (Open/A/B)							<b>NOTES:</b>
Duct Blaster: Leakage to outside (CFM50): (If pressure less than 50 Pa, ref CRF factor)							
Fan Pressure (Pa):							
Duct Blaster: Total Leakage in (CFM50):							
<b><i>duct leakage not to exceed 10% CFM50 x floor area (sq. ft); OR must be reduced by 50% by comparing leakage to the outside before and after sealing.</i></b>							
<b>EXHAUST FAN FLOWS</b>							

DIAGNOSTIC DATA FORM

Location	Window?	Damper?	PRE	POST	NOTES:
	Y/N	Y/N	CFM	CFM	
	Y/N	Y/N	CFM	CFM	
	Y/N	Y/N	CFM	CFM	
	Y/N	Y/N	CFM	CFM	
Continuous Flow Rate	Y/N	Y/N	CFM	CFM	

**Combustion Testing**

Outside Temperature (Fahrenheit):	Pre:		CO Level	And /or	Spill/draft Test	Retrofit Action
	Post:		0-25 ppm	And	Passes	Proceed w/ work
<b>Acceptable Draft Formula</b>			26-100 ppm	And	Passes	Recommend CO problem be fixed
Outside temp minus 100 divided by 20 (°F – 100 ÷20)			26-100 ppm	And	Fails at worst case	Recommend service call for appliance and/or house
<b>House Depressurization Limits (HDL)</b>			100-400 ppm	Or	Fails under natural cond	STOP WORK. System must be serviced & prob corrected
Appliance Type	HDL (Pascals)					
Atmospheric Water Heater Only	-2					
Atmospheric Water Heater common vented with Furnace	-3		>400 ppm	And	Passes	STOP WORK. System must be serviced & prob corrected
Gas Furnace/Boiler, Category I or Category I fan assisted, open-combustion appliances	-5		>400 ppm	And	Fails under any cond	EMERGENCY. Shut off fuel to appliance and call for immediate service.
Power Vented Category I appliances	-15					
Direct Vent—Sealed Combustion Category IV appliances	-25		Physical Mechanical/Flue Inspection (i.e. damage, age, general condition):			
Pellet Stoves	-15					
Closed, controlled wood-burning appliances (Woodstoves)	-7					
Fireplace (wood or gas) unlined chimneys on exterior wall	-3					
Fireplace (wood or gas) metal lined insulated or interior chimneys	-4		General House Set-up Description (i.e. IAQ/Health and Safety Issues):			
CO Ambient (in-house)	PRE:	PPM				
POST:	PPM					
CO @ Air Handler (or nearest supply)	PRE:	PPM				
POST:	PPM					

**DIAGNOSTIC DATA FORM**

GAS Line Inspection (flex line pre 1973 requires replacement): Leak Detected?	YES	NO
-If YES, use leak detection solution to verify.		
Leak Flagged?	YES	NO
Leak Repaired?	YES	NO

<b>FURNACE</b> BtU's: __ Kwh: __ Manufacturer: __ Model: _ Serial Number:			<b>WATER HEATER</b> Manufacturer: __ Model: _ Serial Number:		
	PRE	POST		PRE	POST
CO (PPM)			CO (PPM)		
Draft			Draft		
Supply Temp					
Return Temp			NOTES:		
Temp Rise					
Supply Static Pressure					
Return Static Pressure			<b>OVEN</b>	PRE	POST
Total External Static Pressure (must meet manufacturer's specs for new installs)			CO (PPM)		
NOTES:			NOTES:		

Pre Inspection Signature of Qualified Diagnostic Technician \_\_\_\_\_ Date \_\_\_\_\_

—

Post Inspection Signature of Qualified Diagnostic Technician \_\_\_\_\_ Date \_\_\_\_\_

—

## Appendix V: Electrical Inspection Report

### ELECTRICAL INSPECTION REPORT

Client's Name: \_\_\_\_\_ Project #: \_\_\_\_\_

Address: \_\_\_\_\_ Installer Invoice #: \_\_\_\_\_

Home Phone: \_\_\_\_\_ Work: \_\_\_\_\_ Cell: \_\_\_\_\_

Other contact if necessary: \_\_\_\_\_

#### 1. Ceiling:

1. Crown:  OK  Not approved
2. Slopes:  OK  Not approved
3. Rakes:  OK  Not approved

#### Walls:

1. Knee walls:  OK  Not approved
2. Outside Walls:  OK  Not approved

**Under floor:**  OK  Not approved

2. Service Size? \_\_\_\_\_
3. Is the furnace on a dedicated circuit? Y / N
4. Sub Panels: N / Y Location: \_\_\_\_\_
5. Fusing :  OK  Not approved
6. "S" Type Fuses Installed # \_\_\_\_\_ No \_\_\_\_\_
7. Circuit Breakers Installed # \_\_\_\_\_ No \_\_\_\_\_
8. Junction boxes installed # \_\_\_\_\_ No \_\_\_\_\_  
(flying splices repaired)

⇒ **NOTE: ALL FUSING/BREAKERS CONTROLLING ACTIVE KNOB AND TUBE WIRING MUST NOT EXCEED 15 AMPRE** ⇐

Name of Installer: \_\_\_\_\_ Date of Inspection: \_\_\_\_\_

Name of Inspector: \_\_\_\_\_ License #: \_\_\_\_\_

Installer Comments: Repairs and Cost estimates: \_\_\_\_\_

\_\_\_\_\_

Agency's Auditor's Comments: \_\_\_\_\_

\_\_\_\_\_

## Appendix W: Insulation R-Values

<b>Material</b>	<b>Type</b>	<b>R-Value per inch</b>	<b>Density lbs./cu.ft.</b>
Fiberglass	Batts/ loose fill	2.6-4.3	.04-1.6
	Dense packed	3.6-4.4	1.0-2.5
	Duct board	4.0-4.4	4.0
Mineral Wool	Batts	3.0-3.6	1.5-4.0
	Loose fill	2.6-3.4	1.5-2.5
	Rigid board	4.0-4.4	4.0-5.0
Cellulose	Loose fill	3.2-3.6	1.2-2.5
	Dense-pack	3.0-3.4	3.5-4.5
	Spray-on	2.9-3.4	2.8-3.8
Vermiculite	Loose fill	2.1	2-5
Perlite	Loose fill	2.1	4-8
Polyisocyanurate	Rigid board	5.6-7.6	1.6-2.0
Polyurethane Spray foam	Hi-density (closed cell)	6.0-7.0	2.0-2.5
	Lo-density (open cell)	3.5-3.8	0.5
Polystyrene	Rigid board – expanded (EPS)	3.6-4.2	0.9-2.0
	Rigid board – extruded (XPS)	5.0	1.6-2.0

## **Appendix X: Federal Material Specifications and Standards**

TABLE 1:

<u>Subject</u>	<u>Applicable Federal Specifications</u>
Mineral Fiber Blankets / Batts	HH-I-521F
Mineral Fiber Loose-Fill	HH-I-1030B
Cellulose Loose-Fill *	HH-I-515D
Perlite	16 CFR 1209
Polystyrene Board	HH-I-524C
Polyurethane and Polyisocyanurate Board	HH-I-530A
Federal Trade Commission Labeling Rule	16 CFR 460
Safety Specification for Architectural Glazing Materials	16 CFR 1201 ANSI Z97.1
Glass Float or Plate, Sheet, Figured (Flat, for glazing, mirrors, or other uses)	DD-G-451D
Glass, Plate (float), sheet figured, and Spandrel (heat strengthened and fully tempered)	DD-G-1403B
Caulking, Silicone Rubber	TT-S-001543A
Caulking, Single Component: Polysulfide or Polyurethane	TT-S-00230C
Caulking, Multiple Components: Polysulfide or Polyurethane	TT-S-00227E
Caulking, Single Component: Acrylic Terpolymer	TT-S-00230C

\* Oregon law requires that a U.L. label be on every bag of cellulose loose fill insulation used.

## MISCELLANEOUS EQUIPMENT AND MATERIAL SPECIFICATONS

TABLE 2:

<u>Subject</u>	<u>Applicable Federal Specifications</u>
Surface Burning Characteristics of Building Materials	ASTM E-84-80
Behavior of Materials in a Vertical Tube Furnace at 750 C	ASTM E-136-79
Thermal Conductivity (Guarded Hot Plate)	ASTM C-177-76
Thermal Conductivity (Heat Flow Meter)	ASTM C-518-76
Moisture Absorption of Building Materials	ASTM C-272-53
Water Vapor Transmission of Thick Materials	ASTM C-355-73
Aluminum Combination Storm Windows for External Application	ANSI/AAMA 1002.10-1980
Aluminum Windows	ANSI/AAMA 302.9-1977
Wood Windows	ANSI/AAMA I.S. 2-80
Polyvinylchloride Prime Windows	ASTM D-4099-82
Rigid Polyvinylchloride Profile Extrusions	NBS/PS 26-70
Sealed, Insulating Glass Units	ASTM E-774-81
Dew / Frost Point of Sealed Insulating Glass In Vertical Position, Test Method 4	ASTM E-576-76
Aluminum Sliding Glass Doors	ANSI/AAMA 402.9-1977
Wood Sliding Patio Door	ANSI/NWMA I.S. 3-83
Ponderosa Pine Doors	ANSI/NWMA I.S. 5-73
Douglas Fir, Western Hemlock, and Sitka Spruce Doors and Blinds	FHDA 7-79
Dimensional Standard for Insulated Steel Door Systems	ISDSI 100-79
Air Infiltration Standard for Insulated Steel Door Systems	ISDSI-101
Installation Standard for Insulated Steel Door Systems	ISDSI-102
Water Resistance Standard for Insulated Steel Door Systems	ISDSI-104
Mechanical Performance Standard for Insulated Steel Door Systems	ISDSI-105
Finish Performance Standard for Insulated for Insulated Steel Door Systems	ISDSI-106
Hardness of Plastics and Electrical Insulating Materials	ASTM D0785-76
Electrodeposited Coatings of Zinc on Iron and Steel	ASTM B-633-78
Electrodeposited Coatings of Cadmium on Steel	ASTM A-165-80
Haze and Luminous Transmittance of Transparent Plastics	ASTM D-1003-77
Air Infiltration Tate Test	ASTM E-283-73
Water Penetration Test	ASTM E-331-75
Caulking, Latex	ASTM C0834-76
Low Voltage Room Thermostats	NEMA DC 3-1978
Dehumidifiers	AHAM DH-1/ANSI B149.1-1972
AHAM 1980 Directory of Certified Dehumidifiers January 1980 or latest revision	Edition No.1

## **Appendix Y: Referenced Organizations**

- A. AAMA - American Architectural Manufacturers Association, 35 East Wacker Drive, Chicago, Illinois 60601; (312) 782-8256
- B. AHAM - Association of Home Appliance Manufacturers, 20 North Wacker Drive, Chicago, Illinois, 60606; (312) 984-5800
- C. ANSI - American National Standards Institute, 1430 Broadway, New York, New York, 10018; (212) 354-3300
- D. ASHRAE - American Society of Heating, Refrigeration, and Air-Conditioning Engineers, 1791 Tullie Circle NE, Atlanta, Georgia 30329; (404) 636-8400.
- E. ASTM - American Society of Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103; (215) 299-5400
- F. CPSC - U.S. Consumer Product Safety Commission, 1111 18th Street NW, Washington, DC 20207.
- G. FHDA - Fir and Hemlock Door Association, Yeon Building, Portland, Oregon 97204; (503) 224-3930.
- H. FTC -Federal Trade Commission, Pennsylvania Avenue at 6th Street NW, Washington, DC 20580
- I. HVI - Home Ventilating Institute, 4300-L Lincoln Avenue, Rolling Meadows, Illinois 60008; (312) 359-8160.
- J. IGCC - Insulated Glass Certification Council, Attention Claude Robb, Industrial Park, Courtland, New York 13045; (607) 753-6711.
- K. ISDSI - Insulated Steel Door Systems Institute, 1230 Keith Building, Cleveland, Ohio 44115; (216) 241-7333.
- L. NEC - National Electric Code
- M. NEMA - National Electrical Manufacturers Association, 2101 L Street NW, Washington, D.C. 20037
- N. NFPA - National Fire Protection Association, 470 Atlantic Avenue, Boston, Massachusetts 02210; (617) 482-8755.
- O. NWMA - National Woodwork Manufacturers Association, 205 West Touay Avenue, Park Ridge, Illinois 60069; (312) 823-6747.
- P. NVLAP -U.S. Dept. Of Commerce, National Voluntary Laboratory Accreditation Program, National Bureau of Standards, Washington, DC 20234.
- Q. PSTC - Pressure Sensitive Tape Council, 1800 Pickwick Avenue, Glenview, Illinois 60025; (312) 724-7700.

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### **Appendix Y: Referenced Organizations**

- R. Residential Energy, Cost Savings and Comfort for Existing Buildings, Second Edition, Saturn Resource Management, 324 Fuller Ave., N-13, Helena, MT 59601 (406) 443-3433
- S. SGCC - Safety Glazing Certification Counsel, 1640 West 32nd Place, Hialeah, Florida 33012 (305) 558-1242.
- T. SIGMA- Sealed Insulated Glass Manufacturers Association, 111 East Wacker Drive, Chicago, Illinois 60601, (312) 644-6610.
- U. The Energy Conservatory, 2801 21<sup>st</sup> Ave. S., Suite 160, Minneapolis, MN 55407 (612) 827-1117
- V. UBC - Uniform Building Code, International Conference of Building Officials, 5360 South Workman Mill Road, Whittier, California 90601; (213) 699-0541.
- W. UL - Underwriters Laboratory, 333 Pfinsten Road, Northbrook, Illinois 60062; (312) 272-8800.
- X. UMC- Uniform Mechanical Code
- Y. USDOE - U.S. Department of Energy, Washington D.C. 20585; (202) 252-5000
- Z. Your Mobile Home, Energy and Repair Guide for Manufacture Housing, Saturn Resource Management, 324 Fuller Ave., N-13, Helena, MT 59601 (406) 443-3433

## **Appendix Z: Glossary**

**Air barrier** - Any part of the building shell that offers resistance to air leakage. The air barrier is effective if it stops most air leakage. The surfaces at which most of the air leakage of a house is stopped (usually 45 pa. or more when the house is pressurized to 50 Pascals); not always the same surface as the thermal boundary.

**Air changes at 50 Pascals (ACH 50)** - The number of times that the complete volume of a home is exchanged for outside air when a blower door depressurizes the home to 50 Pascals.

**Air handler** - A steel cabinet containing a blower with heating and/or cooling coils connected to ducts that transports indoor air to and from the air handler.

**Air sealing** - is a systematic approach to “tightening” a dwelling units conditioned envelope (or building shell), to reduce uncontrolled heat loss through air leakage points present in the shell.

**Air-to-air heat exchanger** - A mechanical ventilation device which exchanges air inside a conditioned space with outside air and transfers the heat contained in one air stream to the other air stream.

**Air turbine** - An attic ventilator with attached blades which allow prevailing winds to spin the turbine. This increases the volume of air removed from the attic space.

**Air velocity** - The speed at which air moves through a duct measured in feet per minute.

**Amp** - A unit of measurement of the flow of electrical current.

**Attic exhaust fan** - A ventilating device connecting the attic space to the residence's conditioned space. The fan ventilates by drawing cool outside air into the residence and exhausting warm inside air through attic vents.

**Automatically retractable door bottom closure** - A form of weatherstripping that is spring loaded so that it will seal between the door and the floor or threshold when the door is closed, but will retract as the door is opened to prevent its rubbing on the floor or carpet.

**Back draft damper** - A damper, installed near a fan that allows air to flow in only one direction.

**Back drafting** - Continuous spillage of combustion gases from combustion appliances.

**Backer rod** - Polyethylene Foam rope used as a filler in gaps for caulking.

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### **Appendix Z: Glossary**

**Batt/blanket insulation** - Flexible strips or rolls of preformed insulation, with or without a vapor retarder facing.

**Bi-metal** - Two metals with different rates of expansion that are fastened together. When heated or cooled they will warp and can be made to open/close a switch or valve.

**Bite** - The distance the edge of any glazing material penetrates the frame supporting the glazing in windows or doors.

**Blower door** - A device to create a pressure difference between inside and outside or two areas of building in order to estimate air flow or air pressures. Sometimes called a blower door fan.

**Blown insulation** - Loose-fill insulation blown in by special pneumatic equipment.

**Boiling point** - the temperature at which the addition of any additional heat will begin a change of state from a liquid to a vapor.

**Boot** - A duct section that connects between a duct and a register or between round and square ducts.

**British Thermal Unit (Btu)** - The amount of heat necessary to change the temperature of one pound of pure water one degree Fahrenheit.

**Building cavities** - The spaces inside walls, floors, and ceilings between the interior and exterior sheathing.

**Building permit** - An authorization issued by Agency, city, or state officials allowing a specific type of construction at a particular location.

Carbon monoxide - A colorless, tasteless, odorless gas that is a by product of incomplete combustion.

**Caulking** - A compound used to provide an airtight seal at the points of contact between different types of building materials, thereby preventing infiltration and heat loss.

**Cellulose insulation** - An insulation material treated with flame retardant and made from used newsprint or virgin wood fiber.

**CFM 50 (cfm 50)** - The number of cubic feet per minute of air flowing through the fan housing of a blower door when the house pressure is 50 pascals (0.2 inches of water). This figure is the most common and accurate way of comparing the airtightness of buildings that are tested using a blower door.

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## **Appendix Z: Glossary**

**Chimney effect (or flue effect)** - Is essentially a powerful stack effect occurring inside a chimney or flue caused by the rising of air due to temperature derived weight differences; the rising of air caused by temperature derived weight differences in air.

**Clock or setback thermostat** - A programmable device regulating the demand on the heating or cooling system by automatically switching from one temperature or control level to another.

**Combustion air** - Air that chemically combines with a fuel during combustion to produce heat and flue gases, mainly carbon dioxide and water vapor.

**Conditioned space** - The space within a building that is heated or cooled by an active space heating/cooling system.

**Condensation point** - The temperature at which the removal of any heat will begin a change of state from a vapor to a liquid.

**Conduction** - The transfer of heat from molecule to molecule within a substance.

**Convection** - The transfer of heat by a moving fluid.

**Coverage label** - The label from a bag of loose-fill insulation describing the size of area, depth, weight, and R-value that the material will provide.

**Crawlspace** - The space between the ground and the first floor of the residence in residences not constructed with a basements or "slab on grade" foundation.

**Cross member** - A structural steel piece that connects the main beams of a mobile home.

**Crossover duct** - A duct connecting the plenums and duct systems of the two halves of a double-section mobile home.

**Cross ventilation** - Placement of vent openings so that air flows in one vent, over the insulated space, and out the other vent. Air flow occurs naturally due primarily to wind.

**Cubic Foot** - cu. ft.

**Dew point** - Is the temperature at which air becomes saturated and the vapor condenses to water.

**Dehumidifier** - A mechanical device which removes moisture vapor from the air.

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#### **Appendix Z: Glossary**

**Direct vent** - Method of venting appliance whereby all air for combustion is derived directly from the outside atmosphere and all flue gases are discharged directly to the outside atmosphere.

**DOE** - The United States Department of Energy.

**Door sweep** - The bottom horizontal portion of a door frame used for adjusting its overall height to fit an existing doorjamb. A bottom expander usually includes some type of weatherstripping.

**Dormer** - A window set upright in a sloping roof, or the roofed projection into which a window is set.

**Double strength glass** - Glass of higher physical strength than single-strength glass, usually 1/8 inch thick.

**Draft diverter** - A device located in gas appliances flue pipe used to moderate or divert draft that could extinguish the pilot light or interfere with combustion.

**Dry rot** - See Wood Decay.

**Emittance** - The ability of a material to emit radiant energy from its surface. Also called emissivity.

**EPDM (Ethylene Propylene Diene Monomer)** - flexible rubber membrane roof system used primarily on mobile homes in weatherization.

**Evaporator** - The heat transfer coil of an air conditioner or heat pump that cools the surrounding air of the refrigerant inside the coil evaporates and absorbs heat.

**Fan control** - A bimetal thermostat that turns the furnace blower on and off as it senses the presence of heat.

**Fenestration** - Window and door openings in a buildings walls.

**Finish material** - A building material, such as gypsum board or wood paneling, exposed to the living space and used to contain or hide construction components.

**Fill tube** - A plastic tube, 1-3" in diameter, connected to the end of a blower hose and inserted into a closed building cavity.

**Flame spread rating** - Used to indicate the rate at which flame will spread across the surface of a given material. The higher the number, the faster the flame spread. The rating is determined by Standard Test ASTM E-84-80.

**Flashing** - Sheet metal strips installed to prevent water leakage over windows, doors, etc., and around chimneys and other roof details.

**Flue** -The ducting to exhaust gases from the furnace.

**Foot** - ft.

**Freezing point** - The temperature at which the removal of any heat will begin a phase change from a liquid to a solid.

**Frost line** - The maximum depth of the soil where water will freeze during the coldest weather; the maximum depth in the ground at which freezing will typically occur in a given geographical area.

**Furring** - Thin strips of board fastened to the wall to provide an air space for insulation and support for wall materials (such as gypsum board) to be installed over insulation.

**Gable vents** - Vents located in the wall section of the attic at or near the peak of the roof.

**Glazing** - Glass or other transparent material (such as vinyl) used in windows and doors. Also, the act of fitting a window with glass or similar material.

**Ground cover** - A polyethylene sheet (or similar material which has low water-vapor permeance) overlaying the ground within a crawlspace.

**Gypsum board** - Rigid sheets of gypsum attached to the framing of a building to provide a surface suitable for painting or other finishing. Gypsum is made of a hydrated sulfate of calcium occurring naturally in sedimentary rock. Also referred to as sheet rock, dry wall, and gypsum board.

**Heat** - A form of energy causing the agitation of molecules within a substance.

**Heat rise** -The number of degrees of temperature increase that air is heated as it is blown over the heat exchange. Heat rise equals supply temperature minus return temperature.

**Heat recovery ventilators (HRV) sometimes called Air-to-Air Heat Exchanger (AAHXV)** - Provide balance of air flows and transfer part of the heat from exhaust side to incoming air.

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**Heat transfer** - The three methods of heat transfer are conduction, convection and radiation.

**High limit switch** - A bimetal thermostat that turns off the heating element of a furnace if it senses a dangerously high temperature.

**House pressure** -The difference in pressure between the indoors and outdoors as measured by a gauge on the blower door when the blower door is operating.

**HUD code** - The US Department of Housing and Urban Development's standard for new manufactured homes, known as the Manufactured Home Construction and Safety Standards.

**Humidistat** - A device which controls the operation of a humidifier or dehumidifier or fan based on the relative humidity present in the air, similar to the way a thermostat works to control temperature.

**HVAC** - An acronym for heating, ventilating, and air conditioning.

**I-Beam** - One of two steel beams shaped like a capital i. These beams provide the main support for the mobile home and are the main structural parts of the chassis or trailer.

**Inch** – in.

**Interlocking metal weatherstripping** - A two piece unit comprised of a metal strip and interlocking metal retainer which creates an interlocking airtight seal when a door is closed.

**Infiltration** - Uncontrolled inward air leakage through cracks or openings in building elements, windows, and doors. Infiltration is only one half of the air leakage process. For any air infiltration there shall also be air escaping somewhere else (exfiltration.).

**Insulated door** - An exterior door containing some type of effective insulation (usually foam) and designed specifically to reduce heat loss through conduction.

**Insulation** - A material which restricts heat transfer from a hot object to a cold object, usually by creating air spaces.

**J-rail** - The metal strip that clamps a metal mobile home roof down to the siding around the perimeter of the roof and also acts as a miniature rain gutter.

**Jalousie window** - A window consisting of several slats of glass (similar to Venetian™ blinds) which open simultaneously by means of a crank, common in older mobile homes.

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**Jamb** - The finished side or top piece of a window or door opening.

**Joists** - Closely spaced parallel beams supporting a floor or ceiling.

**Knee wall** - A short wall between an attic floor and a sloping roof.

**Knob and tube wiring** - A wiring method, often concealed in walls and ceilings, using porcelain or ceramic knobs and tubes for the support of single insulated conductors.

**Kilowatt** - A unit of electric power equal to 1000 joules per second or 3412 BTUs per hour.

**Laminated glass** - Two pieces of glass laminated with a plastic sheeting between the glass to help prevent shattering into dangerous shards. This type of glass meets the U.S. Consumer Product Safety Commission Class 2 rating.

**Light** - The glazed parts of a window, also called the windowpane.

**Lineal foot** - Lf.

**Loose-fill insulation** - Insulation material (cellulose, mineral wool, Perlite, vermiculite) manufactured in a loose form, which is usually blown or poured into place.

**Low E** - Low emissivity, a very thin metallic glass coating to resist the loss of radiant heat.

**Low temperature vinyl (weatherstripping)** - Vinyl that is designed to remain pliable under cold weather conditions.

**Low voltage** - Less than 50 volts. Low voltage is frequently used in control signaling circuits and landscape lighting.

**Marriage wall** - The joint between two sections of a double section or triple section home.

**Mastic** - Sealant used for duct tightening.

**Mechanical Ventilator** - Any fan or other motor-driven unit used for ventilating.

**Meeting rail** - The frame located on one edge of an operable glazed light or screen that forms the center rail of a window or door system. Usually interlocks with a companion rail.

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**Multi-glazing** - An arrangement of two or more layers of glass used to reduce heat loss by providing one or more insulating air spaces between them (also see Sealed Insulating Glass).

**Mil** - One one-thousandth of an inch.

**Mineral I fiber** - Thermal insulation material composed of mineral substances such as slag, rock, and glass.

**Net free area** - The net area of unencumbered venting (i.e., the area without screens or louvers) which provides free air access. Abbreviated NFA.

**Noncombustible Insulation** - Insulation of which no part will ignite and burn when subjected to fire and which conforms to ASTM E-136-79.

**Open combustion** - A combustion device that takes its combustion air from the surrounding room air is called open-combustion.

**Orifice** - A hole in a gas pipe where gas exits the pipe to be mixed with air in a burner before combustion in a heating device.

**Outward clinching staple** - A staple driven by a special staple gun that will stitch belly paper together without wood backing (also called "stitch stapler").

**Pascal (Pa)** - A unit of measurement for small air pressures caused by blower doors and wind.

**Passive ventilation** - Natural air movement due to temperature differences (using no moving parts such as fans, etc.) caused by convection.

**Perimeter insulation** - Insulation installed on the sidewalls of a crawlspace or around the edges of a slab on grade.

**Perlite** - Loose fill insulation material which is made from expanded volcanic rock.

**Perm rating** - The unit of measurement of permeance to water vapor. It is equivalent to one grain of water vapor passing through a membrane 1 square foot in area when the vapor pressure across the area is 1 inch of mercury. The lower this number, the smaller the amount of water vapor that can pass through the membrane. The rating is determined by Standard Test ASTM E-96-72.

**Plenum** - The piece of ductwork that connects the furnace to the main supply duct.

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**Polyisocyanurate** - A closed-cell polymer foam often pale yellow in color; similar to polyurethane.

**Polystyrene** - A closed-cell polymer foam containing a mixture of air and polymer gases, usually white or pale blue in color.

**Polyurethane** - A closed-cell polymer foam containing gases instead of air.

**Pony wall** - A short wall, usually on top of a foundation.

**Poured insulation** - Loose insulation installed by spreading over a surface.

**Prehung window or door** - A unit manufactured with the frame already fitted.

**Pressure drop** - The decrease in pressure due to friction of air as it passes through a forced air system.

**Pressure/friction channels** - Spring or tension-loaded channels in the moving parts of a window; allows window openings to be variable without latches or other supports.

**Prime window** - The original window to which a storm window or multiglazing is added to provide greater thermal resistance.

**Radiation** - The transfer of heat without an intervening medium between all objects.

**Rake attic** - Side attics found in story and a half finished attics or "knee wall" attics.

**Recessed fixture** - An electrical fixture (usually a light) mounted recessed within a wall or ceiling.

**Recessed soffit** - A ceiling soffit containing recessed fixtures.

**Refrigerant** - A substance which produces a refrigerating effect while expanding or vaporizing; refrigerant (common refrigerants are R-22 and R-410A); a special fluid used in air conditioning and heat pumps that heats air when it condenses from a gas to a liquid and cools air when it evaporates from a liquid to a gas.

**R-value** - A unit of resistance to heat flow. It is expressed as temperature difference required causing heat to flow through a unit area of a building component or material at a rate of 1 heat unit per hour. The inverse of U-value or measurement of heat flow.

**Rock wool** - Thermal insulation material composed of threads or filaments of slag, produced by reprocessing the residual materials from metals smelting.

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**Safety glass** - Either laminated or tempered glass.

**Sashes** - The parts of a window, generally movable, in which panes of glass are set.

**Sealed combustion** - Used to describe a combustion appliance like a furnace or water heater that draws combustion air from outdoors and has a sealed exhaust system.

**Sealed insulating glass** - A window unit with two or more panes of glass hermetically sealed together at the factory. During the process, the air between the panes is dried so condensation is prevented inside the unit (also known as multiglazing).

**Sealer** - A paint, lacquer, varnish, or similar material applied to exposed or fresh-cut wood to prevent degradation when installed outside.

**Sequencer** - A bi-metal switch that turns on the elements of an electric furnace in sequence.

**Single strength glass** - Standard 3/32-inch-thick pane of glass.

**Setback periods** - The period during which time controlled thermostats reduce the demand on a heating or cooling system by changing the set point temperatures.

**Slab on grade** - A concrete foundation poured directly on the ground.

**Soffit** - The area between the end of the roof overhang and the edge of the residence or, more generally, the underside of any architectural feature, usually not structural.

**Soffit vent** - An attic vent located in the soffit under the eaves of the roof overhang.

**Spillage** - Temporary flow of combustion gases from a dilution device.

**Spot ventilation** - The exhausting outside of moisture or other pollutants at the location they are produced, usually a bath or kitchen fan.

**Square foot** - sq. ft.

**Square inch** - sq. in.

**Static pressure** - the force of the air being pushed by the fan on the sides of the duct usually measured by drilling a small hole in the duct and inserting a static tap connected to a manometer.

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**Storm Window** - A unit consisting of glazing installed in a window opening either inside or outside a prime window, creating an insulating air space to reduce heat flow.

**Supply air** - Air that has been heated or cooled and is then moved through the ductwork and out the supply registers of a home.

**Sweep** - A vertical, flat, flexible weatherstripping attached to the base of a door.

**Therm** - A unit of energy equal to a 100,000 BTUs or 29.3 kilowatt-hours.

**Thermal boundary** - consists of the air barrier and the insulation, which should be in substantial contact with each other.

**Thermal break** - A relatively low heat/cold conductive material separating two highly conductive materials.

**Thermal bridging** - Rapid heat conduction resulting from direct contact between very thermally conductive materials.

**Thermo couple** - A bi-metal junction electric generator used to keep the safety valve of an automatic gas valve open.

**Tempered glass** - Glass that has been treated so that when broken it forms many bead like pieces with no jagged edges and meets the U.S. Consumer Product Safety Commission Class 2 rating.

**Termination bar** - A metal strip that clamps the rubber roof membrane at the edge of the roof and wall in a rubber roof installation.

**Thermostat** - A device for automatically controlling a heating or cooling system through regulation of interior air temperature.

**Thermal conductance** - See U-value.

**Threshold** - A piece of wood, stone, metal, etc., placed on the door sill, or the part stepped over when passing through the door.

**Total pressure** - Total pressure in the duct equals static pressure plus velocity pressure.

**Ton of refrigeration** - Equivalent to 12,000 BTUS per hour or the refrigeration equivalent to the melting of one ton of ice per 24 hours or 288,000 BTU per day.

**UMC** - Uniform Mechanical Code.

**Unconditioned space** - Space within a building which is not heated or cooled by an active system: or, the outside.

**U-value** - Measurement of the thermal conductive capacity of a material. It is the reciprocal of the R-value. The amount of heat flow in BTUs per hour per sq. ft. per degree Fahrenheit temperature difference on either side of a body (BTUH/ft<sup>2</sup>/°F).

**Vapor retarder** - A material that retards the passage of water vapor. A film, laminated duplex paper, aluminum foil, paint coating, or other material which restricts the movement of water vapor from an area of high vapor pressure to one of lower pressure. Material with a perm rating of 1.0 or less is normally considered as vapor retarder; commonly referred to as vapor barrier.

**Vapor diffusion** - The flow of water vapor through a solid material.

**Ventilation** - The intentional exchange of air, usually for pressure building cavities, spot ventilation of bathrooms and kitchens or whole house ventilation for occupants.

**Ventilation shielding** - Rigid material installed at ventilation points or recessed fixtures in the attic to keep loose insulating materials from blocking or sloughing into the area.

**Vermiculite** - An expanded mineral insulation consisting of a mica-like substance which expands when heated. The resulting granules are generally used as loose-fill insulation.

**Visible transmittance** - The percent of light transmitted by a glass assembly.

**Visqueen** - Polyethylene film vapor retarder commonly used as a ground cover.

**Volume** - Vol.

**Water pipe heaters** - Electric resistance wire encased in plastic which can be wrapped around water pipes in unconditioned spaces to prevent freezing, usually thermostatically controlled.

**Wind loads** - The pressure exerted on windows and other large areas from the force of the wind.

**Weatherstripping** - Material such as vinyl, foam, or metal strips installed to prevent air infiltration through cracks around movable portions of windows and doors.

**Whole house plenum** - An enclosed crawlspace used in lieu of return or supply ducts in a forced air heating/cooling system.

**Whole house ventilation (system)** - A mechanical system to insure sufficient fresh air for occupants. Not to be confused with building cavity ventilation such as attic or crawlspaces. Exhaust whole house systems use an upgraded bath fan, timer and fresh air inlet ports in each room.

**Wood decay** - A degradation of wood caused by wood destroying fungus. Sometimes called "dry rot".

**Zonal pressure** - Is the diagnostic test to determine location and effectiveness of a buildings pressure boundary or air barrier.

## **Appendix AA: Global Worker Safety**

1. Prevention through design: Design will be incorporated to eliminate or minimize hazards (e.g., material selection, access to equipment for installation and maintenance, placement of equipment, ductwork and condensate lines)  
(SWS 2.0100.1a)
  
2. Hand Protection: When necessary, durable and wrist-protecting gloves will be worn that can withstand work activity.  
(SWS 2.0100.1b)
  
3. Respiratory Protection:
  - 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.

Note: Consult Safety Data sheets for respiratory protection requirements.  
(SWS 2.0100.1c)

4. Electrical Safety:
  - All electric tools will be protected by ground-fault circuit interrupters or be double insulated.
  
  - 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, NFPA70E will be consulted

- Any fixture, ballast, line voltage control, receptacle, or circuit modification will be performed by a licensed electrical professional in accordance with ANSI/NFPA 70 or as required by the authority having jurisdiction. Workers will comply with ANSI/NFPA 70E. All OSHA standard practices will be followed.

(SWS 2.0100.1d, 2.0105.2a)

5. Carbon Monoxide:

- All homes will have an operable 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)  
(SWS 2.0100.1e)

6. Protective Clothing:

- Safety Data Sheets (SDS) and OSHA regulations will be consulted for equipment and protective clothing would be worn if contaminants are present (e.g. insulation material).
- Eye protection will always be worn (e.g., safety glasses, goggles if not using full-face respirator)  
(SWS 2.0100.1f)

7. Confined Space Safety:

- Spaces with limited ingress and egress and restricted work area will be considered confined space.
- Access and egress points will be located before beginning work.
- Inspection will be conducted for hazards, such as damaged or exposed electrical conductors, mold, sewage effluent, friable asbestos or fiberglass, pests, and other potential hazards.
- Adequate ventilation will be provided.  
(SWS 2.100.1g)

8. Power Tool Safety

- 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 tools must be maintained in proper operating condition with all guards securely in place.

- 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  
(SWS 2.0100.1h)

#### 9. Chemical Safety

- Hazardous materials will be handled in accordance with manufacturer specifications or Safety data Sheets (SDS) and OSHA standards to eliminate hazards associated with volatile organic compounds (VOCs), sealants, insulation, contaminated drywall, dust, foams, asbestos, lead, mercury, and fibers.
- Appropriate personal protective equipment (PPE) will be provided to workers.
- Workers will be trained on how to use PPE.
- Workers will be expected to always use appropriate PPE during work.  
(SWS 2.0100.1i)

#### 10. Ergonomic Safety

- 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  
(SWS 2.0100.1j)

#### 11. Hand Tool Safety

- Hand tools will be maintained in safe working order and used for intended purpose.  
(SWS 2.0100.1k)

#### 12. Slips Trips and Falls

- Caution will be used around power cords, hoses, tarps, and plastic sheeting.

- Precautions will be taken when ladders are used, when working at heights, or when balancing on joists.
- Walk boards will be used when practical.
- When scaffolding is used, manufacturer set-up procedures will be followed.
- Appropriate footwear and clothing will be worn.  
(SWS 2.0100.1l)

### 13. Heat and Thermal Stress

- Ensure staff is aware of risks during extreme weather including the symptoms of heat stroke, heat exhaustion, and hypothermia.
- Appropriate ventilation, hydration, rest breaks, and cooling equipment will be provided.
- 911 will be dialed when necessary.  
(SWS 2.0100.1m)

### 14. Fire Safety

- Ignition sources will be identified and eliminated if necessary. (e.g., turn off pilot lights and fuel supply)
- Use of flammable material will be reduced and fire-rated materials will be used.  
(SWS 2.0100.1n)

### 15. Asbestos Containing Materials

- Assess potential asbestos hazard; if unsure whether material contains asbestos, obtain a sample using Oregon DEQ sampling protocols and have a qualified asbestos testing lab assess the material.
- If suspected ACM is in good condition, do not disturb.

- If suspected ACM is damaged (e.g., unraveling, frayed, breaking apart), immediately isolate the area(s).
- For suspected ACM that is damaged or that must be disturbed as part of the retrofit activity, contact an asbestos professional for abatement or repair in accordance with federal, state, and local requirements; only a licensed or trained professional may abate, repair, or remove ACM.
- When working around ACM , do not:
  - Dust, sweep, or vacuum ACM debris
  - Saw, sand, scrape, or drill holes in the material
  - Use abrasive pads or brushes to strip materials
- Asbestos abatement or repair work should be completed prior to blower door testing; exercise appropriate caution when conducting blower door testing where friable asbestos or vermiculite attic insulation is present to avoid drawing asbestos fibers into the living space (i.e., use positively pressurized blower door testing) unless the material has been tested and found not to contain asbestos. (SWS 2.0100.1o)

#### 16. Lead Paint Assessment

- 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. (SWS 2.0100.1p)

#### 17. Site Security

- Work site will be secured to prevent unauthorized entry.
- Temporarily disconnected equipment will be locked up and tagged out.
- All loose or unbagged trash and unused materials will be removed from work site daily. (SWS 2.0100.1q)

#### 18. Crawl Space Safety

- The source of all contaminants (e.g., sewage, dead animals, needles) will be corrected, repaired, or removed before performing weatherization work that requires complete access to the crawl space.
  
- If appropriate, the contaminant will be neutralized and/or a protective barrier will be installed in the area.

(SWS 2.0100.1r)