BONNEVILLE POWER ADMINISTRATION

2014 BPA Residential Weatherization Specifications

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1 General Requirements

These requirements and best practices apply to existing residential (retrofit) weatherization for electrically heated single family and manufactured homes. Single family homes include buildings with 1-4 units in a structure up to three stories.

Contractors must also comply with all applicable state and local codes, HUD code, and federal regulations as appropriate. When a federal, state or local code or regulation exceeds the requirements provided here, that code or regulation applies. If the federal, state or local codes or regulations don't exceed these requirements, then these requirements apply.

In manufactured homes, all combustion appliances except gas cooking appliances and gas clothes dryers, must be sealed-combustion or have supply-air ducted from outdoors directly to the appliance. Fireplaces and wood burning stoves must have tight-fitting glass or metal doors that cover the entire opening of the firebox.

All homes that have any weatherization measures installed should receive these documents.

1. Care for Your Air: A Guide to Indoor Air Quality, EPA
    - *http://www.epa.gov/iaq/pdfs/careforyourair.pdf*
2. Indoor Air Quality Homeowner Disclosure Form
    - *http://rtf.nwcouncil.org/subcommittees/res/IAQDisclosureFinal.pdf*

1.1 Material and Installation Requirements

Weatherization contractors must install all measures in a safe, durable, and effective manner. The following are minimum requirements for selecting and installing weatherization materials.

- Contractors must install all materials according to the manufacturer's instructions.
- All materials must resist environmental degradation according to how they're used and their exposure to environmental factors.
    - Materials used in weatherization must resist corrosion if exposed to corrosive materials.
    - Materials used in weatherization must resist mold and rot if exposed to ground moisture or a foundation.
    - Materials used in weatherization must resist degradation from ultraviolet light if exposed to ultraviolet light.
    - Materials used in weatherization must be compatible with other elements and materials for the sake of durability (for example: won't react chemically).
- Structural members and building components must be free of decay and must be structurally sound before weatherization measures are installed in their vicinity.
- Contractors must warrant all weatherization materials, products, and labor against failure due to manufacturing and installation defects for a period of at least 2 years from the installation date. *Exception*: sealed, insulated-glass units must be warranted against failure of the seal for a minimum of 5 years. The contractor must provide a written warranty, including the installation date, to the

Homeowner or Homeowner Designee. Contractors may supply manufacturers' printed warranties to satisfy a part of this requirement.

- The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Handbook of Fundamentals is the accepted standard for R-value/U-factor of materials used by contractors. Products that vary from ASHRAE are acceptable if they comply with current Federal Trade Commission (FTC) certifications, testing and labeling rules, and have independent laboratory testing that indicates the product's R–value/U-factor.
- Use The National Fenestration Rating Council (NFRC) Certified Products Database (CPD) to determine the U-factors for windows and doors.
- Insulation materials must meet the requirements of the Federal Trade Commission Labeling Rule (16 CFR 460).
- The UL label or equivalent label must appear on every bag of loose fill cellulose material. It must include the file number (R-number) of the manufacturer and the issue number for labels purchased. This ensures adherence to the requirements of CPSC cellulose regulation 16 CFR 1209, which includes critical radiant flux, smoldering combustion, settled density, and corrosiveness.
- Thermal insulation must meet the requirements listed below. Certain requirements refer to voluntary standards such as ASTM International for specific test methods or physical properties. For purposes of compliance with these weatherization requirements, the referenced voluntary standards are mandatory.

Table 1 - Standards for Insulation Materials

Insulation Material	Standard
Mineral Fiber Blankets/Batts	ASTM C 665
Mineral Fiber Loose Fill	ASTM C 764
Cellulose Loose Fill	ASTM C-739, CFR 1209, CFR 1404
Perlite	ASTM C-549 (ASTM C-728)
Vermiculite	ASTM C-516-96e1
Polystyrene Board	ASTM C-578
Polyisocyanurate Board	ASTM C 591 (ASTM C-1289, TYPE 1 OR TYPE 2)
Spray Polyurethane Foam	C 1029-96
Cellular Glass Board	(ASTM C 552)

1. Comply with fire-barrier requirements in local building codes, according to whether insulation is installed in an occupied area of the home or in an intermediate zone, such as an attic or crawlspace.

a. In occupied rooms, contractors must cover combustible insulation, such as foam insulation, with a thermal barrier such as half-inch drywall.

b. In intermediate zones, contractors may install insulation without a covering, unless the local code or the local building inspector requires the contractors to cover the insulation with a thermal barrier or an ignition barrier.

2. Caulk must conform to the standard listed below or be a material demonstrating equivalent performance.

Table 2 - Specifications for Caulking and Sealants

Caulking or Sealant	Specification
Silicone Rubber	TT-S-1543A
Polysulfide or Polyurethane (single component)	TT-S-230C
Acrylic Terpolymer (single component)	TT-S-230C
Polysulfide or Polyurethane (multiple component)	TT-S-227E
Butyl Rubber	TT-S-1657
Acrylic Latex	ASTM C834
Silyl Terminated Polyether (STPE)	ASTM C920

2 Weatherization Health and Safety Best Practices

Comply with the following health and safety requirements for all weatherization jobs.

2.1 Covering Fibrous Insulation in Intermediate Zones

Whenever fibrous insulation is installed where occupants might access for storage or maintenance, contractors must cover the fibrous insulation with a vapor-permeable air barrier (for example: house wrap, drywall).

2.2 Safety Requirements for Electrical Wiring

New insulation, installed in contact with active knob and tube wiring, must be approved in writing by a licensed electrician.

2.3 Carbon Monoxide Alarms

When contractors perform whole-house air sealing, prescriptive air sealing, or duct sealing, they must verify that the home has a working CO alarm if the home has a combustion appliance.

All CO alarms must be Underwriters Laboratories (UL) listed, Canadian UL (CUL) listed, or equivalent. If the home has no CO alarm, install the alarm according to manufacturer's instructions.

3 INSTALLER RECORD

The installer of any measure covered by this specification manual should complete an Installer Record. Permanently post the Installer Record at the electrical panel, circuit box, or other location approved by the homeowner as a record of work performed. The installer may provide a copy to the utility, and the Installer Record should contain the following information as appropriate.

1. Residence address.
2. Installation date.
3. Name, address and phone number of the Installer.
4. Building component(s) that have been insulated: ceilings, walls, floors, pipes, or ductwork.
5. Square footage of each of the components insulated.
6. Estimated R-values of pre-retrofit insulation and post-retrofit insulation.
7. Area (plus bag count if applicable), added R-value, depth and type (including product name) of insulation installed.
8. A label or chart for any loose-fill insulation showing R-value per inch or R-value at installed depth.
9. A report of air sealing completed, with final whole house leakage test results if applicable. List primary areas or building components that workers air sealed in the report.
10. A report of any duct sealing that was completed, with final duct leakage test results if applicable. List areas with ductwork that were sealed.
11. A list of rough opening areas or dimensions of any windows and doors that were replaced, and U-factors of each window and door.
12. A list and description of any newly installed fans or mechanical ventilation systems, including design airflow rate and control strategy.

4 Attic and Roof-Cavity Insulation

Comply with the following preparation and installation requirements for attic and roof-cavity insulation.

4.1 Preparation for Attic and Roof-Cavity Insulation

Before insulating, contractors must prepare an attic so that weatherization measures are as effective as possible, are durable and long-lasting, and create no negative unintended consequences.

4.1.1 General Attic/Roof Preparation

Remove all degradable and absorbent scrap materials from the attic that might eventually rot and damage the structure, especially wood and cardboard. Repair any water leaks and moisture damage prior to performing work.

4.1.2 Attic Insulation Shields

1. Attach rigid, non-combustible shields to the ceiling structure to maintain a 3-inch clearance around the perimeter of recessed light fixtures and other heat producing fixtures that aren't IC-rated.
2. Insulation shield must extend at least 4 inches above the level of the new insulation and any insulation must be removed from the top and inside of the insulation shield.
3. Contractors may install non-combustible insulation (labeled as meeting ASTM E-136) with no clearance around flues and chimneys if permitted by a local code official.

4.1.3 Insulation Dams

Insulation dams maintain the insulation's full R-value to the edge of an insulated space, and prevent blown insulation from blocking vents or spilling into uninsulated areas or into the living space through the attic access.

Insulation dams must use one of the following two methods.

a. Build dams with rigid materials such as plywood, OSB, foam board, or cardboard. Permanently secure the dam to attic framing. Rigid dams must extend four inches above the final level of the insulation. Use durable materials like OSB or plywood for areas where occupants may need access.

b. Dams made of batts are a good solution when attic framing doesn't allow for construction of a rigid dam. Create dams with fiberglass batts laid flat that are at least 15 inches wide and that create an R-value equal to the R-value of the remainder of the attic.

4.1.4 Pipe Insulation

If water or hydronic pipes won't be covered by at least one inch of attic insulation, wrap the pipes according to *"Hydronic and Water-Pipe Insulation" on page 30*.

4.2 Prescriptive Attic Air Sealing (Optional)

Move insulation as necessary to find and seal all accessible gaps and penetrations between conditioned space and the attic to seal air leaks. Then either cover the leaks with new insulation or replace the original insulation. Follow these instructions to seal air leaks where you find them.

Table 3 - Attic Air Sealing Requirements

Item	Sealing requirements between conditioned and unconditioned space or the outdoors
Attic hatch/door	Install weatherstripping to create an effective air seal between the attic access frame and hatch/door.
Pull down stair cover	Install a gasket or weatherstripping between frame and door or install an airtight cover between the stairs and attic.
Duct penetrations	Apply mastic, caulk, or other airtight seal around the perimeter of duct boots between the boot and the ceiling.
Chases	Install foam, caulking, and rigid barriers to the attic floor or wall. Near heat-producing devices, provide clearances to combustible materials and use fire-rated materials as appropriate.
Recessed cans (non-IC)	Install foam, caulk or another airtight seal between fixture and ceiling. Or install an airtight drywall box or another non-flammable air-sealed insulation box. Maintain a 3 inch clearance on all sides and above the fixture. Extend the box above the new insulation so that no insulation covers the top
Recessed Cans (IC)	Seal between the interior finish and the fixture. Don't seal over the fixture with spray foam or seal openings in the fixture. An airtight box or prefabricated cover is acceptable. Insulate over the fixture with fibrous insulation.
Bath fans	Apply foam, caulk, or other airtight seal around the fixture perimeter.
Bath fans with heat source	Use fire-resistant caulk. If the opening is larger than 1 inch, span the gap with sheet metal.
Electrical and plumbing penetrations	Apply foam, caulk or other airtight seal around perimeter of electrical fixtures and plumbing penetrations.
Top plates	Seal all accessible drywall-to-top-plate connections, wood-to-wood seams, and penetrations through the top plate with foam or caulk.
Drop soffits	Install rigid material to close off the soffit from the attic, and seal the rigid material with foam or caulk.

Table 3 (Cont.) - Attic Air Sealing Requirements

Item	Sealing requirements between conditioned and unconditioned space or the outdoors
Knee wall doors	Attach weatherstripping permanently to create an effective air seal between the attic access frame and the hatch or door. Install a latch or handle if necessary.
Floor-joist cavities under knee walls	Install rigid material between the joists; then foam or caulk the perimeter of each joist space. Alternatively, roll a fiberglass batt to fit tightly between each joist and cover with foam.
Open wall cavities	Install foam, caulk, or rigid board at the top of balloon-framed walls and to open walls between split-level attic areas.

The following locations are considered "not accessible."

a. Where building structure or mechanically fastened materials block access.

b. Top plates located adjacent to eave line.

c. Top plates covered by more than 5 inches of loose-fill insulation or a combination of loose-fill and batt insulation.

4.3 Passive Attic Ventilation

Each separate attic space must meet the following requirements. *Exception*: Code officials may determine that attic ventilation is unnecessary because of local conditions.

1. The net free area (NFA) of attic vents must be no less than $^{1}/_{150}$ of the area of the space ventilated.
2. The NFA may be reduced to $^{1}/_{300}$ of the area, provided that at least 40% and no more than 60% of the required ventilating area is provided by vents located within 3 feet of the ridge.
3. Vents must have screens with an opening of not more than ¼ inch and not less than $^{1}/_{16}$ inch.
4. Vents on exposed vertical surfaces must have louvers.
5. Contractors must not install air turbines in order to comply with the ventilation requirements of this section. However, contractors may include the net free area of existing air turbines by estimating the net free area of the air turbine in a fixed position (not turning).

4.3.1 Baffles for Eave and Soffit Vents

Comply with these requirements when installing eave baffles.

1. Remove any existing insulation or other debris from the eave or soffit vents.
2. Baffles must be rigid and air impermeable.
3. Baffles must extend at least 4 inches above the final level of insulation.
4. Maintain an opening between the baffle and the roof sheathing equal to or greater than the area of the soffit vent.

5. Install the baffle far enough into the rafter bay to reach the exterior side of the top plate in order to achieve the best R-value possible above the top plate.
6. Fasten the baffles to the roof rafters with no less than $^{9}/_{16}$-inch galvanized staples or roofing nails.
7. Address continuous soffit ventilation with one of the following methods.
   a. Where a continuous soffit vent exists, install a baffle in each rafter bay.
   b. Install baffles, equally spaced along the soffit. Seal the unbaffled rafter bays with a rigid, moisture-resistant material.

4.3.2 Vented Vaulted Ceilings

Avoid installing air-permeable or vapor-permeable insulation in contact with the roof deck (except in the case of finished attics described in *"Sloped Roof Cavities in Finished Attics" on page 16*).

1. If insulation is added to a vented vaulted ceiling or a vented cathedral ceiling, maintain a 1- inch air space between the insulation and the roof sheathing.
2. Each roof cavity must have an upper vent and a lower vent, allowing air to flow continuously and effectively dry the roof deck.

4.4 Exhaust Fans

New and existing exhaust fans must vent directly to the outdoors (through a roof jack, gable, or wall) and never into an attic or into another location within the home.

4.4.1 Exhaust Fans and Ducts

Ducts for kitchen fans and bathroom fans must comply with all the following requirements.

1. Exhaust ducts must be sheet metal or HVAC flex-duct and insulated to a minimum of R-4 if in unconditioned space. Vinyl coil ducts must be replaced.
2. Any newly installed exhaust ducts must be sized according to *"Exhaust Fan Prescriptive Duct Sizing" on page 46*.
3. All exhaust fans must vent to the outdoors. Ducts must be mechanically fastened using sheet metal screw or clamps and be substantially airtight. Mechanical fasteners must not interfere with dampers.
4. Exhaust fan ducts should be adequately supported to prevent sagging, be as straight as possible to maximize effective air flow, and have no more than two 90-degree turns, or equivalent.
5. Kitchen exhaust ducts must be made of 28-gauge galvanized steel, stainless steel, aluminum, or copper
6. Existing rigid or flexible metal vent ducts may remain if they are free of holes and kinks and are otherwise in good condition.

4.4.2 Clothes Dryer Exhaust

Like ducts for exhaust fans, dryer exhaust ducts located in attics must vent to the outdoors and comply with these requirements.

1. Dryer exhaust ducts that pass through attics must be vented to the outdoors, sealed to prevent exhaust air from entering the building, have a back-draft damper, and terminate in a code-approved vent cap.
2. New dryer ducts must be rigid metal, securely connected with mechanical fasteners, permanently supported, and sized according to the manufacturer's specifications. To prevent blockage with lint, don't connect new dryer vent ducts with screws. Instead, use a metal clamp or UL-rated foil tape to secure dryer duct connections.
3. Exhaust systems must comply with local code and manufacturer specifications, not exceed 25 feet, be as straight as practical, and sloped downward to allow condensate toward the termination fitting to drain.

4.5 Attic Insulation: Installation

4.5.1 Blown Attic Insulation

Install loose-fill insulation to the surface between the conditioned space and attic with a uniform R-value. Comply with these steps when installing loose-fill attic insulation.

1. Install one insulation depth ruler for every 300 square feet of attic area. Depth rulers should face the attic entrance.
2. Pack insulation against the eave baffle or roof deck to achieve the highest possible R-value in places where the full intended thickness of insulation won't fit.
3. Install insulation to a consistent depth. Level the insulation if necessary.

4.5.2 Batt-Type Insulation

Install batts in contact with the surface between the conditioned space and attic, cut to fit, placed tightly together with no gaps except those required for clearance around heat-producing fixtures.

1. Install baffles and shields prior to installing batt-type insulation.
2. Cover the exterior of the top plates of exterior walls. You may compress the batts at the eaves if necessary to cover the top plates.

4.5.3 Foam Insulation

In an open attic, a sloped roof cavity, or an attic knee wall, both spray or rigid foam are acceptable types of insulation, provided they meet the following requirements.

1. The foam insulation must meet the minimum requirements for R-value. Contractors must install the foam insulation in contact with the surface that separates attic and conditioned space.
2. The foam insulation must comply with thermal-barrier and ignition-barrier code requirements for "foam plastics," as defined by the local building code or allowed by local building officials.

4.5.4 Vapor Retarders

If fiberglass batts with a vapor-retarder are installed in an attic with no existing insulation, the vapor retarder must touch the attic side of the drywall or plaster ceiling. If insulation already exists in an attic, don't install batts with a vapor retarder on top of the existing insulation.

4.5.5 Interior Attic Access Doors

Access doors must be insulated and sealed in a durable and effective manner. Comply with the following requirements for interior access doors to the attic when insulating the attic.

1. Permanently attach weatherstripping to the attic-access door or frame to create an effective air seal between the door frame and the door. Repair air leaks or replace the door prior to insulating. Insulate vertical access doors to at least R-13 and horizontal access doors to at least R-30 using one of these three methods.
    a. Attach batt-type insulation to the door with twine, wire, or vapor-permeable house wrap. Attach the twine, wire, or house wrap to the door in order to secure the batt. A vapor-permeable air barrier material must cover the fiberglass door insulation if occupants enter the attic for storage or maintenance.
    b. Attach foam board using construction adhesive to achieve R-30 or greatest attainable R-value that still allows the door to function.
    c. Install R-5 or greater rigid foam insulation between the access door and a rigid protective material (plywood or other durable rigid material) attached over the entire insulation area. Seal the rigid insulation around the perimeter to the access door using caulk, adhesive or spray foam. Air seal the access cover assembly using weather stripping around the entire perimeter.
2. Install a dam around the attic hatch opening to maintain the full level of ceiling insulation to the edge of the opening and to prevent insulation from falling into the living space. Comply with the following requirements to build a dam.
    a. Frame the opening with dimension lumber, OSB, or plywood. Permanently attach the framing and extend it at least 4 inches above the final level of insulation. Don't use cardboard or foam board to dam around access hatches. Cardboard and foam board aren't durable materials where they are readily accessible to occupants.
    b. Place a minimum of 15-inch wide insulation batt laid flat, with an R-value equal to that specified for the attic, tightly around the perimeter of the access opening. Install the dam with no gaps or voids. Maintain a consistent level of insulation in all outward directions from the access opening, including corners.

4.5.6 Pull-Down Stairs

Comply with these requirements when a pull-down-stair assembly separates the attic from the conditioned space of the house.

1. Weatherstrip and insulate all pull-down stairs in heated areas to a minimum of R-10.
2. Contractors may install new pull-down stair assemblies with a minimum R-5 insulation rating. The insulation must be between conditioned space and the attic stair assembly and gaskets or weatherstripping must minimize air leakage.

4.5.7 Exterior Attic Access Doors

Any outside access door with continuous exposure to the outdoors must be weatherproof and animal-proof.

4.5.8 Walls in Attic Areas

Comply with all of these requirements when insulating walls in attic areas.

1. Install wall insulation prior to installing ceiling insulation. This insulation must be a minimum of R-13 in a 2 x 4 cavity, and R-21 in a 2 x 6 cavity.
2. When adding new insulation over existing wall insulation, completely fill the cavity.
3. If you install a vapor retarder, install it in contact with the heated surface.
4. Cover new or existing attic wall insulation with a durable, vapor-permeable air barrier material to prevent air penetration of the insulation and to ensure that the insulation is held in full contact with the wall. Fasten the air-barrier material so that it permanently supports the knee wall insulation.
5. Insulate knee wall access door and hatches to R-13 and weatherstrip them to create an effective air seal. Pre-manufactured foam-core doors are an acceptable option. If side attic area will be accessed (used for storage), cover fibrous insulation with a vapor-permeable material.

4.5.9 Floored Attics

Comply with these requirements when insulating under floor boards of floored attics.

1. Cavities below decked storage areas must be insulated to the highest practical level.
2. Light fixtures below decked storage areas must be IC-rated.
3. Insulate under attic floor boards with tightly packed blown fibrous insulation. To fill the cavities, lift the boards or drill holes no more than 4 feet apart. Avoid over-filling the cavities, because the pressure can damage the ceiling materials below.
4. If installing insulation in non-decked areas of the attic, prevent loose-fill insulation from falling onto the storage deck using a dam according to *"Insulation Dams" on page 9*.
5. Sweep or vacuum spilled insulation off the storage decking after installation.

4.6 Unvented Attics

Insulating the underside of the roof to create an unvented attic requires special consideration to protect the roof from moisture. Comply with these requirements when insulating the underside of a roof.

1. Insulate roofs to the maximum R-value possible or a minimum of R-24.
2. The unvented attic must be entirely within the building's thermal envelope. Seal the roof deck and any gable walls to insure that the unvented attic is insulated and air sealed on all sides.
3. The insulation must be an air-impermeable vapor retarder to prevent condensation on the bottom side of the roof deck caused by moisture movement around or through the insulation. Or, the insulation must be air-impermeable and have a separate vapor retarder installed in contact with the interior surface of the insulation.
4. There must be no vapor retarder installed in the ceiling (attic floor).

5. Rigid foam insulation installed in an unvented attic or roof cavity must be sealed at the perimeter of the foam and at all seams to create a continuous air barrier. If the insulation will be covered, the Utility will perform an in-progress inspection to verify the insulation board is properly installed and sealed. The in-progress inspection must be documented in the house permanent file.
6. Most foam insulation products don't meet requirements for thermal and ignition barriers, and must be protected from fire danger.
   a) If the attic is occupied, used for storage, or accessed through a full-sized stairway and door, cover the foam insulation with a thermal barrier such as drywall or E84 Class-A-Certified intumescent paint or an FSK-faced fiberglass blanket classified E-84.
   b) If people only enter the attic to service utilities through a hatch, cover the spray foam insulation with an ignition barrier, such as any of the items in (a) above, 1½ inches of fiberglass or cellulose, or other practice as allowed by building code.

Rigid foam insulation installed in an unvented attic or roof cavity must be sealed at the perimeter of the foam and at all seams to create a continuous air barrier. After the rigid board is installed and prior to covering the insulation, the utility will perform an in-progress inspection to verify the insulation board is properly installed and sealed. The in-progress inspection must be documented in the house permanent file.

4.7 Sloped Roof Cavities in Finished Attics

A finished attic is often a living space with unfinished attics on the sides and above connected by a sloped ceiling cavity. Insulation may fill the entire cavity if the sloped ceiling is located between upper (peak) and lower (rake) vented attic spaces. Sloped-roof insulation must meet these requirements.

1. The insulated sloped ceiling must be less than 8 feet in length from the knee wall to the attic area under the apex of the roof.
2. Install a vapor-permeable containment material at the lower cavity openings.
3. Cover the finished side of the slope with a continuous rigid air barrier between the conditioned living space and the insulation, such as sheet rock. This prevents moisture from infiltrating the insulation.
4. All recessed fixtures in the insulated assembly must be UL rated for Insulation Contact Airtight (ICAT).

4.8 Exterior Roof Insulation

Contractors must comply with these requirements when installing exterior roof insulation.

1. Insulate over the roof deck or roofing with rigid foam board insulation to a minimum of R-20.
2. Don't insulate over vented cavities (for example: vaulted ceilings with vented spaces, attics, sloped ceilings connected to attics and/or knee wall spaces).
3. Roof drainage systems must function after insulation is installed. Suppliers of expanded polystyrene often taper the foam to route water to the existing drains or scuppers.
4. Contractors should replace recessed lights in insulated roof cavities with fixtures labeled Insulation Contact and Air Tight (ICAT) rated.

5. All penetrations through the roof covering and all joints between the roof covering and vertical surfaces (for example: walls, chimneys, etc.) must be flashed and sealed to prevent water leaks.
6. After the contractor installs the rigid insulation and before the insulation is covered by the sheathing and roofing, the utility should perform an in-progress inspection to verify the insulation board is properly installed and sealed. The in-progress inspection must be documented in the house permanent file.

5 Manufactured Homes: Ceiling and Roof Insulation

Insulate to the maximum level possible. Check with local code or utility weatherization programs for minimum insulation levels.

5.1 General Requirements for Insulating Ceilings and Roofs

Comply with these general requirements for insulating the roof cavities and attics of manufactured homes.

1. Seal all ceiling penetrations before insulating ceiling cavities.
2. If the ceiling cavity contains a non-ducted return-air system, seal the opening to the attic and provide return air, either through ductwork or vent to the main area of the home.
3. For vented roof cavities, comply with all applicable requirements in *"Attic and Roof-Cavity Insulation" on page 9*.
4. Insulate ceiling cavities under flat or crowned metal roofs by completely filling them with blown-in fiberglass insulation. Seal all existing attic ventilation except existing roof jacks.
5. Insulate attics under pitched roofs to R-38 when possible and ventilate the attic to comply with *"Passive Attic Ventilation" on page 11*.
6. Exhaust fans and ducts along with dryer ducts, located in the roof cavity, must comply with requirements in *"Exhaust Fans" on page 12*.

5.2 Exterior Roof Insulation

Contractors must comply with these insulation requirements when adding exterior roof insulation.

1. Install exterior roof insulation to a minimum of R-7.
2. Fully insulate the ceiling cavity below and eliminate all vents. Don't install insulation over vented ceiling cavities or over cavities containing air spaces.
3. Roof systems must effectively drain water away from the structure. All penetrations through the roof covering and all joints between the roof covering and vertical surfaces must be flashed (for example: walls, chimneys, plumbing vents).
4. Other methods of installing exterior roof insulation must be approved by the utility in writing prior to beginning the work.

5.3 Insulating Manufactured-Home Roof Cavities

5.3.1 Preparing to Blow a Manufactured-Home Roof

Reinforce weak areas in the ceiling and seal all penetrations. Take steps to maintain safe clearances between insulation and recessed light fixtures and ceiling fans. See *"Preparation for Attic and Roof-Cavity Insulation" on page 9* for more information.

5.3.2 Ramada Roofs

A ramada roof is a free standing (self supporting) covering over a manufactured home. Comply with these requirements when adding insulation under a ramada roof and on top of the manufactured home's original roof.

1. The ramada roof must be weatherproof and joined to the manufactured home (per local code) to create an enclosed attic cavity. This prevents the entry of weather and pests.
2. The attic cavity must meet the ventilation requirements of the site-built specifications.
3. Extend all exhaust-fan ducts, plumbing vent stacks, etc. to the outside and install a termination in accordance with local code requirements.
4. Open the original roof cap of the manufactured home to allow a full fill of insulation inside the attic cavity. Install the insulation above the original roof to provide an installed level of R-38. Don't seal the openings in the original roof.
5. Seal all ceiling penetrations before the insulation is installed.

6 UNDERFLOOR INSULATION

Comply with these requirements when insulating the floor-joist cavities above a crawlspace or unconditioned basement.

6.1 Preparation for Underfloor Insulation

When a contractor installs underfloor insulation in a site-built home, these preparatory steps are required.

1. Remove all degradable and absorbent scrap materials from the crawlspace, especially wood and cardboard. These materials may eventually rot and damage the structure. Repair any water leaks and moisture damage prior to performing work.
2. If standing water is found in the crawlspace, drain it before insulating the floor. Repair chronic bulk water problems or plumbing leaks before the floor is insulated.

6.1.1 Dryer Exhaust

Dryer exhaust ducts must comply with these requirements.

1. Dryer exhaust ducts that pass through crawlspaces must be vented to the outdoors, have a back-draft damper, and terminate in a code-approved vent cap.
2. New dryer ducts must be rigid metal, securely connected with mechanical fasteners, permanently supported, and sized according to the manufacturer's specifications. To prevent blockage with lint, don't connect new dryer vent ducts with screws. Instead, use a metal clamp to secure dryer duct connections.
3. Exhaust systems must comply with local code and manufacturer specifications, not exceed 25 feet, be as straight as practical, and slope downward to allow condensation to drain toward the termination fitting, if possible.

6.1.2 Downdraft Exhaust Fans

Downdraft exhaust ducts must exit through the foundation or exterior wall and may have one 90-degree turn. The vent cap must have $^{1}/_{4}$-inch mesh screen to prevent rodents from entering, and there must be at least one back-draft damper in the assembly.

6.1.3 Ground-Moisture Barrier

Verify that a ground-moisture barrier is present in the crawlspace or install a new ground-moisture barrier before installing underfloor insulation. Comply with these requirements when verifying, installing, or retrofitting a ground-moisture barrier

1. Acceptable materials for a ground-moisture barrier include the following.
   a. 6-mil black polyethylene.
   b. UV-stabilized and opaque polyethylene.
   c. Existing black 4 mil polyethylene may remain if it's in good condition.
2. Overlap seams by 12 inches.
3. Treat unconditioned basements with exposed soil the way you would a vented a crawlspace. Cover the exposed soil with a ground-moisture barrier.

6.1.4 Crawlspace Ventilation

Any moisture that enters a crawlspace from any source must be drained or vented to the outdoors. Crawlspaces weatherized with underfloor insulation must be vented by openings in exterior foundation walls or rim joists.

1. The total net free area of foundation vents must not be less than 1 square foot for each 150 square feet of underfloor area as a default standard.
2. Vent openings must be covered with corrosion-resistant wire mesh with openings not more than $^{1}/_{4}$-inch in width or length.
3. Where soil moisture isn't considered excessive, a code official or utility representative may reduce the ratio to 1 square foot of vent for each 1500 square feet of underfloor area. Vent openings must be located close to corners and provide cross ventilation in the crawlspace.

6.1.5 Water Pipes in Crawlspaces

If water or hydronic pipes won't be covered by at least one inch of attic insulation, wrap the pipes according to *"Hydronic and Water-Pipe Insulation" on page 30*. Fiberglass batts used in floor insulation must be cut to fit around pipes with no voids or compression.

6.1.6 Indoor Access Doors for Underfloor Areas

Insulate any interior crawlspace access door to at least R-25 for horizontal openings and to at least R-13 for vertical openings. Comply with these requirements for indoor access doors as part of underfloor insulation.

1. Weatherstrip all inside access doors and hatches.
2. Use staples and twine to securely fasten the fiberglass batts to access doors to ensure the effectiveness and durability of the insulation. Insulate as much of the door as possible without affecting the door operation. Fiberglass batts must be covered with a vapor-permeable air barrier material when regular access by people occurs.

Pre-made doors or hatch assemblies that meet either of these two descriptions may be installed.

1. Install R-5 or greater rigid insulation between the access cover and a rigid protective material (plywood or other durable rigid material) under the entire insulation area. Insulation must be sealed around the perimeter to the access cover using caulk, adhesive, or spray foam. Attach the rigid protective material mechanically to the access cover to securely hold the insulation in place. Tightly seal the access cover assembly using weatherstripping around the entire perimeter.
2. Foam core doors with a minimum R-5 insulation rating (manufactured for exterior use) used in vertical wall underfloor access door installations are permitted. Gaskets or weatherstripping must minimize air leakage around the entire door perimeter.

6.1.7 Exterior Access Doors for Underfloor Areas

Any outside access must not allow water or pests to enter a crawlspace. Exterior access doors must meet these requirements.

1. The door, its hinges, and associated fasteners must be made from weather-resistant materials.
2. Vertical accesses may be screened if they are used as part of the crawl-space ventilation system.
3. Horizontal basement and crawl-space hatch covers must shed water away from the foundation and crawl-space entrance.
4. Wood in contact with soil or concrete must be moisture- and rot-resistant.
5. Existing covers are acceptable, provided that they are in good condition, weather-resistant and vermin-resistant.

6.2 Prescriptive Crawlspace Air Sealing (Optional)

Comply with the following table when performing air sealing in a crawlspace.

Table 4 - Crawlspace Air Sealing Requirements

Item	Sealing requirements between conditioned space and unconditioned space or the outdoors
Crawlspace hatch/door	Permanently attach weatherstripping to create an effective air seal between the crawlspace hatch door and its frame. Install rigid framing material and weatherstripping if the hatch isn't supported by a frame on all 4 sides.
Chases	Seal with foam, caulk, or rigid moisture-resistant material to the floor or wall. Use fire rated materials at chimneys and flues.
Duct penetrations	Seal with mastic, caulk, or other airtight seal around perimeter of duct boots between the boot and the subfloor.
Plumbing and electrical penetrations	Seal with foam or caulk. Use a rigid, moisture resistant material to span gaps larger than 1".
Other open cavities	Use rigid material to cover openings greater than 1". Seal rigid material to the floor with caulk.
Sill plate/stem wall	Seal the sill plate to the stem wall connection with foam or caulk.
Rim joists	Foam or caulk perimeter of each rim joist. (Only for rim joists between basements and crawlspaces.)

6.3 Installing Underfloor Insulation

Insulate the floor to the maximum amount practical. Check with local code or utility weatherization programs for minimum insulation requirements.

6.3.1 Installing Fiberglass Batt Insulation

Comply with these requirements when installing fiberglass batts in floor-joist spaces of the underfloor.

1. Cut batts to fit around water pipes, drain pipes, or other obstructions so no gaps or voids exist.
2. If the installed batt has a vapor retarder facing (Kraft paper or foil-Kraft), the facing must be installed against the floor sheathing.
3. Support fiberglass batts so that the batts remain in contact with the sub-floor, and remain in place for the life of the home. You can compress the insulation in order to achieve continuous contact with the bottom of the floor.
4. Support batts no more than 3 inches from the ends. Small batt pieces also need support.
5. Use one of the following materials to support floor insulation.
   a. **Wood lath**—Wood lath needs to be a minimum of ¼ x 1 inch for spans up to 48 inches. Spans greater than 48 inches must use at a minimum nominal 1 x 2 lumber.
   b. **Twine**—Twine must be non-stretching polypropylene or polyester.
   c. **Wire**—Wire must be stainless steel, copper or an equivalent material of similar corrosion resistance, with a minimum diameter of 0.040 inch (size 18 AWG).
6. Self-supporting wire hangers aren't acceptable.
7. Fasteners for floor-insulation support materials must meet the following requirements.
   a. Staples must be driven with a power-actuated stapler to achieve at least $^{5}/_{8}$ inch penetration. Hand stapling isn't a durable fastening technique and isn't allowed.
   b. Fasteners for lath, twine or wire may be hot-dipped galvanized nails, screws or corrosion-resistant staples that are at least 18-gauge and long enough to penetrate wood at least $^{5}/_{8}$ inch.

Table 5 - Spacing Requirements for Underfloor Fiberglass Batt Supports

Spans	Maximum Spacing
24 inches or less	18 inches apart
48 inches	12 inches apart
60 inches	8 inches apart
72 inches	6 inches apart

Fasten support systems to the underside of floor joists. Joists may be skipped, but the maximum span of skipped joists cannot exceed 48 inches. The spacing must be 12 inches or less.

6.3.2 Installing Blown Insulation

Comply with these requirements when blowing insulation into the floor-joist spaces of a site built home.

1. Blow only fiberglass or rock wool loose-fill insulation in a floor cavity.
2. Use an insulation restrainer, like one of these below, to hold the blown insulation in the floor cavity.
   a. Webbing or netting designed for restraining blown insulation.
   b. A vapor-permeable polyolefin house wrap material.
   c. Foam board insulation, especially in cold damp locations to prevent moisture condensation in the fibrous insulation.
3. Use wood strips to support the flexible or semi-flexible retainer material unless that material with its fasteners can support the floor insulation permanently without sagging.

6.3.3 Installing Spray Foam Floor Insulation

Foam insulations must meet thermal and ignition barrier requirements for "foam plastics," as detailed by the local building code and enforced by local building officials.

Spray foam insulation typically needs no support. When installing fiberglass batts or blown fiberglass underneath foam, as additional floor insulation or as an ignition barrier, support the fiberglass insulation. See *"Installing Fiberglass Batt Insulation" on page 23* or *"Installing Blown Insulation" on page 24* for more information.

6.3.4 Walls Between Conditioned Space and Underfloor Spaces

Comply with the following requirements when installing underfloor insulation.

1. If the floor joist cavities are open between the conditioned and unconditioned spaces, block with a rigid material and seal with caulk or foam. Air seal the walls including any cavities between the floor joists.
2. Insulate the walls to a minimum of R-13 for a 2 x 4 cavity, and R-21 for a 2 x 6 cavity.
3. When no wall exists, construct an insulated and airtight wall.

6.4 Protecting Underfloor Insulation

Protect underfloor insulation for unskirted crawlspaces and cantilevered floors with an air barrier.

7 MANUFACTURED HOMES: UNDERFLOOR INSULATION

Check with local code or utility weatherization programs for minimum insulation levels. Comply with the requirements in this section when insulating the underfloors of manufactured homes.

7.1 Preparation for Underfloor Insulation

Before installing either blown or fiberglass batt underfloor insulation, take these steps to prepare the home.

1. Install a ground cover in the crawlspace.
2. If the floor contains a non-ducted return system, seal the opening to the crawlspace and provide return air, either by installing new return ducts or by installing a vent between the furnace-closet door and the main area of the home.
3. Extend all water drains to the outside of the crawlspace, including condensate drains from air conditioning equipment.
4. Extend all exhaust ducts, such as those for kitchen ranges and dryers, to the outside of the crawlspace. Seal the ducts and their termination fittings to prevent exhausted air from returning to the crawlspace or to the manufactured home when skirting exists.
5. Seal all plumbing penetrations through the rodent barrier or floor before installing underfloor insulation.
6. Water pipes that aren't contained within the thermal envelope by underfloor insulation must be insulated and may be evaluated for heating cable as described in *"Water Pipes in Crawlspaces" on page 21*.
7. If the home has skirting, install a ground-cover moisture barrier before insulating the underfloor as detailed in *"Ground-Moisture Barrier" on page 20* and ventilate according *"Crawlspace Ventilation" on page 21*.

7.2 Blown Underfloor Insulation

In order to successfully install blown insulation, the rodent barrier must be in good or repairable condition. Contractors must comply with these requirements when installing blown floor insulation.

1. Materials used to patch the rodent barrier must be vapor-permeable, durable and capable of supporting the insulation. Repair large holes in the rodent barrier to prevent insulation from falling into the crawlspace from the floor cavity. Stitch-staple repair materials to the rodent barrier, adhere patches with adhesive, or otherwise permanently affix the patches.

2. Blow only fiberglass insulation in the floor cavity of a manufactured home.

7.3 Fiberglass Batt Underfloor Insulation

In homes where the rodent barrier is damaged or missing over significant sections, install fiberglass batts in the floor joists. Batts installed in the floor joists must meet requirements in *"Installing Underfloor Insulation" on page 23*.

Comply with these insulation requirements when adding fiberglass batts to the floor-joist cavity of a manufactured home.

1. Install fiberglass batts to achieve a minimum of R-22 or the maximum R-value achievable with no air space between the insulation and the subfloor. Contractors may compress the batts in order to maintain continuous contact with the bottom of the floor.
2. Protect insulation with a vapor-permeable covering or perimeter skirting. Skirting must be as close to the ground as practical and prevent the entry of animals.

8 Wall Insulation: Site-Built homes

Comply with these insulation requirements when adding insulation to the exterior walls of a home.

8.1 Insulating Unfinished Walls

Comply with the following requirements when insulating unfinished walls.

1. Insulate walls to a minimum of R-13 for masonry or for nominal 4 inch walls and to a minimum of R-21 for nominal 6 inch walls.
2. Consider moisture when selecting insulation materials for below-grade masonry or concrete walls. Don't insulate below-grade masonry or concrete walls with fiberglass batts.

8.2 Installing Blown Insulation

1. Insulate the wall to the highest practical R-value. Fill all cavities in all exterior walls, including small cavities above, below and on the sides of windows and doors.
2. Block wall-mounted heaters to prevent contact with insulation. If you can't install blocking, don't fill the cavity with insulation.
3. Seal all fill holes with a non-shrinking, unvented plug.
   a. Holes that will be covered by siding must be plugged and must be completely covered by the siding. If a plug is partially exposed, for example by falling between two pieces of shake siding, the plug must be covered by a properly-lapped building paper, such as 15-pound asphalt felt, polyolefin house wrap, Kraft paper, or stucco building paper.
   b. Holes drilled through the siding must be plugged, sealed, weatherproof, and ready to paint. If the surface of the plug is below the surface of the siding, the hole must be filled with non-shrinking filler.

8.3 Exterior Continuous Wall Insulation

Comply with these requirements when installing exterior insulation.

1. When applying rigid insulation to the exterior stud surfaces of an open cavity frame wall, fit the insulation together tightly to minimize air leakage.
2. During the exterior retrofit, install a code-approved water-resistive barrier using building paper. Incorporate the window flashing into the water-resistive barrier to provide a continuous drainage plane.

9 HVAC Duct Sealing and Insulation

Comply with these duct sealing and duct insulation requirements

9.1 Duct Sealing

Contractors should comply with the requirements of either Performance Tested Comfort Systems (PTCS) or the BPA Prescriptive Duct Sealing Specifications when sealing ducts. Re-install all floor insulation if it was removed in the course of doing duct sealing.

9.2 Duct Insulation

Contractors must comply with these requirements when installing duct insulation.

1. Properly support ducts before insulating.
2. Ducts must be completely insulated without visible voids or gaps in the insulation covering the duct.
3. Duct insulation must be protected from condensation by a vapor retarder.
4. Replace uninsulated flex-ducts with R-8 flex-ducts.
5. Insulate sheet metal ducts to a minimum R-8. Check with local code or utility weatherization programs for minimum insulation requirements.
6. Insulate all ducts located outside of the conditioned space, including plenums and boots. Use mechanical fasteners, such as permanent plastic straps, nylon twine, or stick pins, to support all duct insulation.
7. Use tape (UL 181 B) to seal the seams in the insulation's facing to provide a continuous air barrier and vapor barrier.

10 Manufactured Homes: HVAC Duct Sealing and Insulation

Comply with these manufactured home duct sealing and duct insulation requirements

10.1 Duct Sealing

Contractors should comply with the requirements of either Performance Tested Comfort Systems (PTCS) or the BPA Prescriptive Duct Sealing Specifications when sealing ducts. Re-install all floor insulation if it was removed in the course of doing duct sealing, then repair or replace the rodent barrier.

10.2 Duct Insulation

1. Where ducts are located outside of the rodent barrier, insulate ducts in compliance with *"Duct Insulation" on page 28*. This is typically limited to the crossover duct.
2. If the rodent barrier has been removed and batt insulation has been installed in the floor, wrap all exposed HVAC ducts, boots and plenums, except flexible ducts, with R-8 insulation. Check with local code or utility weatherization programs for minimum insulation requirements.
3. Support crossover ducts above the ground and protect insulation from contact with the ground. If ground contact is unavoidable, install a minimum R-4 rigid foam insulation between the duct and the ground.

11 Hydronic and Water-Pipe Insulation

Water pipes installed in unconditioned areas can freeze. Insulate exposed water pipes in attics and crawlspaces when installing attic insulation or underfloor insulation to reduce heat loss and protect against freezing. Comply with these requirements when insulating water pipes.

11.1 Materials Requirements

Determine the R-value needed using these guidelines.

Table 6 - Required R-Values of Pipe Insulation

Pipe	Required R-Value
Hydronic heating pipe – One inch or less	3.6
Hydronic heating pipe – Greater than one inch	5.4
Domestic water pipes	3.0

1. Pipe insulation must meet the following requirements.
   a. Pipe insulation materials must be composed of mineral fiber, plastic foam, or other suitable materials designed and manufactured for insulating pipes.
   b. Domestic hot water pipe insulation must be capable of withstanding continuous operating temperatures no less than 180 degrees Fahrenheit.
   c. Hydronic pipe insulation must be capable of continuous operation at 250 degrees Fahrenheit.
   d. The insulation material, any jackets or facings, and adhesive, if used, must be tested as a composite product. It must have a flame-spread rating of 25 or less, and a smoke-developed value of 50 or less when tested in accordance with ASTM E-84.
2. Pre-formed insulation must be properly sized.
   a. The inside diameter of the pre-formed insulation must match the outside diameter of the water pipes.
   b. If the diameter of fittings at connections and corners is larger than the piping, insulate these fittings with insulation that matches their outside diameter or with a properly secured wrap insulation.

11.2 Installation Requirements

Comply with these requirements when insulating hydronic pipes and domestic hot water pipes.

1. Verify that the piping is free from water leaks and properly secured to support the weight of the piping and insulation before installing the insulation.
2. Secure the pipe insulation every 12 inches and within 3 inches of the ends with twine, corrosion resistant wire, or plastic compression ties.

3. Tape isn't a durable material for securing pipe insulation so don't use it for this purpose. Tape can be used to create a continuous air and vapor barrier.
4. Pipe insulation must have a minimum finished thickness of 1 inch. When water pipes run next to a beam or joist and the insulation cannot wrap all the way around the pipe, secure the insulation to the beam at a minimum of every 12 inches.
5. Miter the corners of preformed insulation for a tight fit.
6. Cut and fold the insulation to completely cover all sections of the system without overly compressing the insulation to less than 1 inch thickness or allowing gaps to occur in the insulation.
7. Insulate all piping, joints, elbows, and valve bodies, except those sections of the system that are obstructed by existing wood framing members or other components.
8. Seal hydronic heating pipe insulation at all slits and joints with a tape manufactured for this purpose.
9. If insulation is installed on piping exposed to the weather, the insulation must be moisture resistant, and protected from ultraviolet light and extremes in temperature. A jacket or facing can be installed to protect the insulation from these conditions. Follow the manufacturer's recommendation for outdoor installations.
10. The operating portion of valves must be free of insulation and unobstructed.

11.3 Heating Cable Requirements

Where crawlspaces below insulated underfloors may experience freezing temperatures, contractors may install self-regulating heating cable on exposed supply water pipes before insulating the pipes.

1. Self regulating heating cable must be tested for durability and labeled UL 7468 and ASTM 2633.
2. The heating cable must conform to IEC 216-1 Part 1.
3. Insulate the pipes **after** installing the heating cable.

12 Prime Window, Sliding Glass Door, and French Door Replacements

12.1 General Window Requirements

Comply with these general requirements on all window and patio door replacements. Window requirements also apply to patio doors unless otherwise stated.

1. Replacement windows must be certified and labeled for U-factor in accordance with the simulation, testing, and certification procedures of the National Fenestration Rating Council Incorporated (NFRC).
2. Caulk and prime all exterior wood, including frame, sash, trim, stops and sills on all sides and ends.
3. Support the bottom rail of a patio door within 1/2 inch of exterior edge of the frame. Any wood that touches the ground or concrete must be pressure-treated.
4. Incorporate the replacement window and window opening into the home's water-resistive barrier using proper flashing techniques for each specific window type.
5. Hardware and fasteners must be aluminum, stainless steel, or another noncorrosive material.
6. Seal the structural frame to the window, and seal surrounding gaps and cracks.
   a. Frame: Install caulk or low-expansion foam between window frame and rough opening. Install backer rod or non-expanding foam and caulk where gap is greater than 3/8 inch.
   b. Exposed framing components: Caulk at exposed wood-to-wood framing cracks; remove sash weights, if applicable, and seal and insulate weight channels.
7. Cover gaps of over 3/8 inch between the exterior siding and the window with solid trim material. Fill all exterior or interior voids over 3/8 inch in width or depth with window manufacturer-approved materials, such as non-expanding foam, backer rod, or similar product prior to caulking, if caulking will be applied.
8. Verify that windows operate smoothly and safely.

12.2 Window Installation Requirements

Comply with these requirements when replacing windows.

12.2.1 Replacing Nailing-Fin Windows

Comply with these requirements to install a nailing-fin window securely in the rough opening.

1. At the sill, insert the flashing underneath the existing siding and on top of existing building paper. The bottom nailing fin of the window will cover this flashing. .
2. Install the window by sliding the top fin under the building paper. Side and bottom fins should rest on top of the building paper. Use flat shims to provide a level surface and support under the vertical structural members of the new window frame. Don't allow the fins to support the window's weight.

3. Use fasteners with heads wide enough in diameter to span the holes or slots in the window fin. Avoid over-driving the fasteners or otherwise deforming the window fin.
4. Flash the window with 15-pound felt, house wrap, or a peel-and-stick membrane.
   a) First, flash the side fins of the window, overlapping the sill flashing;
   b) Then, flash the top fin of the window, overlapping the side flashing.
5. Windows that are exposed to wind-driven rain or without overhangs above them should have a rigid head flashing to prevent rainwater from draining onto the window.
   a) If the tops of the windows are already protected by an overhanging metal head flashing, tuck the new flashing behind this head flashing.
   b) If the tops of exposed windows aren't protected by head flashing, insert new metal head flashing behind the existing siding and building paper at the top of the window and over the head trim piece. The head flashing should extend beyond the sides of the window enough to divert water away from vertical joints of the window.
   c) Tuck the head flashing up behind the exterior siding at least 1 inch. Metal head flashing must have a downward bending lip of at least $^{1}/_{4}$ inch on the front and ends.
6. Thoroughly caulk all filler and trim pieces surrounding the replacement window.

12.2.2 Block-Frame or Finless Windows

Comply with the following requirements when installing block-frame or finless windows.

1. If window-weight cavities are present and accessible, remove the weights, fill the cavities with insulation, and seal the cavities.
2. Support block-frame or finless windows under their main vertical supports with shims that level the window.
   a. Use flat shims if the sill surface is flat.
   b. Use tapered shims or a sill angle if the sill surface is sloping.
3. Windows without fins must be secured to the rough opening within 4 inches of each side corner and a minimum 12 inches on center along the remainder of the frame with one of these fastening methods.
   a. Screws fastened through the window frame. Use screws that are designed for fastening block-frame windows.
   b. Jamb clips or plates that are fastened first to the window and then to the opening in separate steps.
4. Protect the existing sill with a metal or plastic sill pan or rigid sill flashing if necessary for drainage and to protect the existing sill that protrudes from the exterior wall. Or, install a new sill as part of the window replacement.
5. Fill any gaps over $^{3}/_{8}$ inch that are between the exterior siding and the block-frame window. Install backer rod in all exterior or interior voids over $^{3}/_{8}$ inch in depth or width before caulking.
6. Caulk around the perimeter of the window to the existing frame to prevent water intrusion.

12.2.3 Flush-Fin Window Replacement

Replace windows in stucco walls using windows with flush fins, also called stucco fins, which have no nail holes. Flush-frame windows are replacement windows that fasten to the window opening and mount directly over the flat siding surrounding the window opening. This flush-fin window- replacement technique is similar to block-frame window installation.

1. If window-weight cavities are present and accessible, remove the weights, fill the cavities with insulation, and seal the cavities.
2. Support the replacement window on the existing sill with one of the following materials.
   a. A flat or tapered continuous wood support.
   b. Flat shims under the window's main vertical supports.
   c. Tapered shims under the window's main vertical supports if the sill is sloping.
3. Apply a sealant that remains flexible to the back of the flush fin of the replacement window in order to seal it to the surface of the exterior wall. Leave a gap in the caulking at the bottom fin for one inch on each side of the window's weep holes to allow water to drain.
4. Windows must be secured to the rough opening within 4 inches of each side corner and a minimum 12 inches on center along the remainder of the frame with one of these fastening methods.
   a. Screws fastened through the window frame. Use screws that are designed for fastening block-frame windows.
   b. Jamb clips or plates that are fastened first to the window and then to the opening in separate steps.

12.3 Safety Glass and Emergency Egress

All windows must meet the following safety glazing and egress requirements. Use safety glazing in locations where the risk of breakage is high. Egress windows are windows with an opening sash large enough for people to use as a fire escape.

Safety glazing requirements apply to replacement windows, replacement patio doors, multi-glazing inserts, and storm windows. Each pane of glass requiring safety glazing must bear the manufacturer's permanent safety glazing label. This label of identification is etched or ceramic-fired on the glazing and clearly visible in one of the corners of the lite.

12.3.1 Hazardous Locations Requiring Safety Glazing

Comply with state and local code for required safety-glazing locations.

12.3.2 Emergency Egress Openings

Where an existing window meets code-required egress requirements, the replacement window must also meet those egress requirements.

13 Prescriptive Air Sealing

This manual includes steps for both prescriptive and whole-house air sealing. Prescriptive air sealing is a series of required steps that may accompany attic or floor insulation measures. Prescriptive air sealing doesn't require a blower door test. In contrast, whole-house air sealing includes a blower door test to obtain a measurement of building tightness before and after air sealing.

Prescriptive air sealing is a list of air-sealing instructions and locations that compliment attic insulation or underfloor insulation. Prescriptive air sealing is a recommended option for attic insulation and underfloor insulation.

- See *"Attic Air Sealing Requirements" on page 10* for air-sealing requirements relating to attic and roof insulation.
- See *"Crawlspace Air Sealing Requirements" on page 22* for air-sealing requirements relating to underfloor insulation.

14 Whole-House Air Sealing

Comply with the following requirements when providing whole-house air sealing.

1. Air leakage testing must be performed by a certified technician. Approved certifications include PTCS, BPI, HERS, and Weatherization Assistance Program trainings.
2. The preliminary blower door test must occur immediately prior to the installation of whole-house air sealing. The post-installation blower door test must occur immediately following the installation of whole-house air sealing measures. *See "Blower Door Air-Leakage Measurement" on page 39*.
3. Seal all accessible and applicable items on the checklists in *"Whole-House Air Sealing Locations"* below. The following locations are considered "not accessible."
   a. Where building structure or mechanically fastened materials block access.
   b. Top plates located adjacent to eave line.
   c. Top plates covered by more than five inches of loose-fill insulation or a combination of loose-fill and batt insulation.
4. Whole-house air sealing requires compliance with *"Evaluating Home Ventilation Levels" on page 40*.
5. If a combustion appliance is present in the home, perform a combustion appliance zone (CAZ) testing in accordance with *"Worst-Case CAZ Depressurization Test" on page 44*.

14.1 Whole-House Air Sealing Locations

Table 7 - Attic Air Sealing Checklist

Item	Sealing requirements between conditioned and unconditioned space or the outdoors
Attic hatch/door	Install weatherstripping to create an effective air seal between the attic access frame and hatch/door.
Pull down stair cover	Install a gasket or weatherstripping between frame and door or install an airtight cover between the stairs and attic.
Duct penetrations	Apply mastic, caulk, or other airtight seal around the perimeter of duct boots between the boot and the ceiling.
Chases	Install foam, caulking, and rigid barriers to the attic floor or wall. Near heat-producing devices, provide clearances to combustible materials and use fire-rated materials as appropriate.
Recessed cans (non-IC)	Install foam, caulk or another airtight seal between fixture and ceiling. Or install airtight drywall box or another non-flammable air-sealed insulation box. Maintain a 3" clearance on all sides and above the fixture. Extend the box above the new insulation so that no insulation covers the top

Table 7 (Cont.) - Attic Air Sealing Checklist

Item	Sealing requirements between conditioned and unconditioned space or the outdoors
Recessed Cans (IC)	Seal between the interior finish and the fixture. Don't seal over the fixture with spray foam or seal openings in the fixture. An airtight box or prefabricated cover is acceptable. Insulate over the fixture with fibrous insulation.
Bath fans	Apply foam, caulk, or other airtight seal around the fixture perimeter.
Bath fans with heat source	Use fire-resistant caulk. If the opening is larger than 1", span the gap with sheet metal.
Electrical and plumbing penetrations	Apply foam, caulk or other airtight seal around perimeter of electrical fixtures and plumbing penetrations.
Top plates	Seal all accessible drywall-to-top-plate connections, wood-to-wood seams, and penetrations through the top plate with foam or caulk.
Drop soffits	Install rigid material to close off the soffit from the attic, and seal the rigid material with foam or caulk.
Knee wall doors	Attach weatherstripping permanently to create an effective air seal between the attic access frame and the hatch or door. Install latch or handle if necessary.
Knee wall transition (under floor paths)	Install rigid material between the joists; then foam or caulk the perimeter of each joist space. Alternatively, roll a fiberglass batt to fit tightly between each joist and cover with foam.
Open wall cavities	Install foam, caulk, or rigid board at the top of balloon-framed walls and to open walls between split-level attic areas.

Table 8 - Crawl Space Air Sealing Checklist

Item	Sealing requirements between conditioned and unconditioned space or the outdoors
Crawlspace hatch/door	Permanently attach weatherstripping to create an effective air seal between the crawlspace hatch door and its frame. Install rigid framing material and weatherstripping if the hatch isn't supported by a frame on all 4 sides.
Chases	Seal with foam, caulk, or rigid moisture-resistant material to the floor or wall. Use fire-resistant materials at chimneys and flues.
Duct penetrations	Seal with mastic, caulk, or other airtight seal around perimeter of duct boots between the boot and the subfloor.

Table 8 (Cont.) - Crawl Space Air Sealing Checklist

Item	Sealing requirements between conditioned and unconditioned space or the outdoors
Plumbing and electrical penetrations	Seal with foam or caulk. Use a rigid, moisture resistant material to span gaps larger than 1”.
Other open cavities	Use rigid material to cover openings greater than 1”. Seal rigid material to the floor with caulk.
Sill plate/stem wall	Seal the sill plate to stem wall connection with foam or caulk.
Rim joists	Foam or caulk perimeter of each rim joist. (Only for rim joists between basements and crawlspaces or outdoors.)

Table 9 - Exterior Wall Air Sealing Checklist

Item	Sealing requirements between conditioned and unconditioned spaces or the exterior
Walls between conditioned and unconditioned areas	Seal connection between floor and wall with caulk if accessible; tape and mud any unfinished drywall.
Plumbing penetrations	Install foam or caulk. Use rigid barrier if opening is larger than 1”.
Doors	Weatherstrip doors and install a door sweep or airtight threshold to create an effective air seal.
Other air leaks identified with a blower door	Caulk or foam electrical boxes, window trim, door trim, and baseboards.

14.2 Air leakage Testing Protocol

For whole-house air sealing, the contractor must do a blower door test immediately before and immediately after the air sealing. Preparing the house for a blower door test involves putting the house in its normal heating-season operation with all interior doors open to the blower door.

1. Identify the location of the thermal boundary and determine which house zones are conditioned.
2. Close all windows and exterior doors, including pass-through wood-box doors and pet doors.
3. Open interior doors so that all indoor areas inside the thermal boundary are connected to the blower door. This could include the basement, conditioned knee wall areas, bonus rooms, and closets.
4. Turn off combustion appliances temporarily.
5. Identify large air leaks that could prevent the blower door from achieving adequate pressure.
6. Comply with these requirements for positioning ventilation openings for a blower door test.
   a. Open all forced-air supply and return registers.

b. Don’t seal exhaust vents with backdraft dampers (for example: dryer vents, exhaust-fan vents, whole-house fans).

c. Temporarily seal exterior exhaust fan vent openings without backdraft dampers (for example: some continuous ventilation systems) for the test.

d. Temporarily seal ventilation supply openings for the test.

7. Combustion appliances: All flue dampers, fireplace doors, and wood burning stove doors must be closed, but NOT sealed. If fireplace or wood-stove doors are leaky and there is a risk of ash or debris being drawn into the home, cover ash with wet newspaper. If ash is still an issue, pressurize the home with the blower door instead of depressurizing the home.

14.2.1 Blower Door Air-Leakage Measurement

Whole-house air sealing requires these steps to quantify air leakage.

1. Set-up the blower door and digital manometer equipment using the manufacturer instructions for depressurization to 50 Pascals.
2. Quantifying air leakage reduction: air leakage reduction is the difference between the CFM_{50} measurements before and after whole-house air sealing.
3. The final CFM_{50} measurement is also used to determine if mechanical ventilation is required.

15 Evaluating Home Ventilation Levels

Contractors who choose to do whole-house air sealing during weatherization must evaluate ventilation following 3 distinct components.

- Whole-building ventilation requirement
- Local exhaust ventilation requirement
- Natural ventilation credit

15.1 Whole-Building Ventilation Requirement

Use either the formula below or the table with common values shown in the *"Whole-House Ventilation Requirements" on page 45* to determine the whole-building ventilation requirement.

1. Determine the floor area of the conditioned space of the home in square feet, including a conditioned basement (A_{floor}).
2. Determine the number of bedrooms (N_{br}).
3. Insert these numbers in the formula below to compute the total ventilation rate (Q).

Whole-House Ventilation Requirement Q(CFM) = $0.03A_{floor} + 7.5(N_{br} + 1)$

15.2 Local Exhaust Ventilation Requirement

Bathrooms need a fan capable of exhausting 50 CFM to remove moisture generated by a shower. Kitchens require a fan with a 100-CFM capacity to remove moisture and pollutants from cooking. Contractors must measure the flow rate of the exhaust fan. If the fan configuration prevents use of airflow measuring devices, contractors may assume $^2/_3$ of the fan's rated flow.

An operable window in a kitchen or bathroom contributes 20 CFM to the local exhaust ventilation requirement.

If the existing exhaust fans and windows don't meet the local ventilation requirement, increase the whole-house ventilation requirement to compensate. Use the formula below to calculate the local ventilation deficit.

Local Ventilation Deficit (CFM) = (Total CFM deficits of kitchen and bathrooms) ÷ 4

15.3 Natural Ventilation Credit

Determine the rate of natural ventilation in the home using the final blower door measurement. If the estimated natural ventilation is less than the whole-house ventilation requirement plus any local ventilation deficit, make up the difference with fan-powered ventilation. The fan-powered ventilation system must provide the difference between the natural ventilation and the required ventilation. Refer to Appendix 3: N-Values for CFM_{50} to CFM_N Conversion.

Natural Ventilation Credit (CFM) = Blower Door Measurement (CFM_{50}) ÷ N

15.4 Mechanical Ventilation Strategies

If natural ventilation is insufficient to meet the requirements calculated in this chapter, contractors must provide the additional ventilation using one of the following fan-powered ventilation strategies.

a. A dedicated exhaust or supply fan running continuously or cycling by automatic control.

b. A bathroom or kitchen exhaust fan running continuously or cycling by automatic control.

c. A central air handler drawing exterior air into its return and cycling by automatic control.

d. A balanced ventilation system such as a heat-recovery ventilator (HRV) or energy-recovery ventilator (ERV).

Mechanical ventilation strategies may be set to run continuously if the fan is rated for continuous operation. There must not be a control switch that makes it easy for an occupant to turn off the mechanical ventilation. If mechanical ventilation is set to run intermittently, there must be at least 2 periods of runtime per day.

16 Mechanical Whole-House Ventilation

All homes receiving whole-house air sealing must comply with the ventilation requirements in *"Evaluating Home Ventilation Levels" on page 40*. This may require installation of a whole-house ventilation system or exhaust fans in kitchens and bathrooms.

16.1 Local Ventilation

In order for ventilation fans to fully evacuate pollutants, ducts must extend to the exterior of the structure, be airtight, and not restrict airflow.

Existing and newly installed local ventilation must meet the following requirements for all homes receiving whole-house air sealing. Existing rigid or flexible metal vent ducts may remain if they are free of holes or kinks and are in otherwise good condition, provided they are sealed and vented to the exterior to prevent exhaust air from entering the attic.

16.1.1 Ducts for Ventilation Fans

New and existing bath, kitchen, exhaust, and whole-house ventilation fans must be sealed, secured and vented to the exterior of the structure. All fans must comply with these requirements.

1. Exhaust ducts must be sheet metal or HVAC flex-duct and insulated to a minimum of R-4 if in unconditioned space. Vinyl coil ducts must be replaced.
2. Any newly installed exhaust ducts must be sized according to *"Exhaust Fan Prescriptive Duct Sizing" on page 46*.
3. All exhaust fans must vent to the outdoors. Ducts must be mechanically fastened using sheet metal screw or clamps and be substantially airtight. Mechanical fasteners must not interfere with dampers.
4. Exhaust fan ducts should adequately supported to prevent sagging, be as straight as possible to maximize effective air flow, and have no more than two 90-degree turns, or equivalent.
5. Kitchen exhaust ducts must be made of 28-gauge galvanized steel, stainless steel, aluminum, or copper
6. Existing rigid or flexible metal vent ducts may remain if they are free of holes and kinks and are otherwise in good condition.

16.1.2 Dryer Exhaust

Dryer exhaust ducts must vent to the outdoors and comply with these requirements.

1. Ducts must have a back-draft damper, and terminate in a code-approved vent cap.
2. New dryer ducts must be rigid metal, securely connected with mechanical fasteners, permanently supported, and sized according to the manufacturer's specifications.
3. Dryer ducts must be as straight as practical, must not exceed 25 feet in length and, where possible, slope downward away from the dryer.
4. To prevent blockage with lint, don't connect new dryer vent ducts with screws. Use a metal clamp or UL-rated foil tape to secure dryer duct connections.

16.2 Mechanical Ventilation Strategies

Comply with the following requirements when installing a whole-house mechanical ventilation system.

1. If fan-powered ventilation is used to meet the whole-house ventilation requirement, measure fan airflow rates and don't assume that the rated airflow is correct. *Exception*: If the airflow measuring device can't be fitted to the exhaust fan, assume that the fan delivers $^{2}/_{3}$ of its rated airflow.
2. The whole-house mechanical ventilation system must either run continuously, or run intermittently on a timer to achieve the same airflow capacity of continuous operation.

16.2.1 Exhaust Ventilation

Bath fans used for meeting the whole-house mechanical ventilation requirement must have automatic controls set to deliver the required amount of whole-house ventilation. Bath fans which also provide local ventilation must have separate controls to deliver local ventilation as needed. Newly installed fans must be rated at 1 sone or less.

16.2.2 Fresh Air Inlets

If a contractor installs fresh air inlets to provide make-up air as part of an exhaust ventilation system, these requirements apply.

1. Locate air inlets, which are part of the ventilation system, a minimum of 10 feet away from known sources of contamination such as plumbing stacks, combustion vents, exhaust hoods, or vehicle exhaust.
2. Place the fresh air inlet so that snow, plants, or other material can't obstruct entering air.
3. Inlets must have rodent/insect screens with mesh between $^{1}/_{16}$ inch and $^{1}/_{2}$ inch in width.

16.2.3 Balanced Ventilation

Energy or Heat Recovery Ventilators installed for whole-house mechanical ventilation purposes must be certified and listed in the *Home Ventilating Institute Directory*, be *ENERGY STAR* compliant, and be rated for continuous operation.

16.3 Combustion Safety-Testing

Contractors must perform a "worst case depressurization test" before and after whole-house air sealing, for all combustion appliance zones (CAZs).

16.3.1 Combustion Safety Standards

If a CAZ fails worst-case depressurization testing before whole-house air sealing, the contractor must inform the homeowner and mitigate the problem as part of the weatherization work scope. If the CAZ fails after the whole-house air sealing, the contractor must mitigate the problem before the project is finished. A CAZ fails the worst-case test if it is depressurized by more than the pressures on the table shown below at worst-case.

Table 10 - CAZ Depressurization Limits for Combustion Appliances

Appliance	Maximum Depressurization
Power-vented or sealed-combustion furnace or boiler; pellet stove with draft fan and sealed vent *	–10 pa (–0.04 IWC)
Gas furnaces and boilers with atmospheric burners	–5 pa (–0.02 IWC)
Oil power burner and fan-assisted (induced-draft) gas *	
Wood-burning appliances	
Atmospherically vented water heater	–2 pa (–0.008 IWC)

16.3.2 Worst-Case CAZ Depressurization Test

Follow the steps below to find the worst-case depressurization level in the CAZ.

1. Verify that all exterior doors, windows, and fireplace damper(s) are closed, and measure the base pressure.
2. Set all combustion appliances to the pilot setting or turn them off.
3. Measure and record the base pressure of each CAZ with reference to outdoors.
4. Turn on the dryer and all exhaust fans and check each CAZ pressure with reference to outdoors.
5. Turn on the air handler, if present, using the "fan on" switch. Leave the air handler on if the pressure in the CAZ becomes more negative after you turn it on.
6. Close interior doors while the air handler is operating to maximize the negative pressure. If closing the door makes the CAZ less negative, open the door for the remainder of the test. Repeat for each door in the home.
7. Measure the worst-case pressure and record it. Compare this number to the table entitled, *"CAZ Depressurization Limits for Combustion Appliances" above* for the tested appliance.

APPENDIX 1: WHOLE-HOUSE VENTILATION REQUIREMENTS

Table 11 - CFM Requirements for Homes

Floor Area (ft^2)	Number of 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

Fan flow in CFM.

APPENDIX 2: EXHAUST FAN PRESCRIPTIVE DUCT SIZING

Use table below to size new exhaust fan ducts correctly.

Table 12 - Exhaust Fan Prescriptive Duct Sizing

	Rated Fan CFM							
	50	80	100	125	150	200	250	300
Duct Dia.	**Smooth Hard Duct - Maximum Duct Length in Feet**							
3”	5	X	X	X	X	X	X	X
4”	114	31	10	X	X	X	X	X
5”	NL	152	91	51	28	X	X	X
6”	NL	NL	NL	168	112	53	25	9
7”	NL	NL	NL	NL	NL	148	88	54
8”	NL	NL	NL	NL	NL	NL	198	133
Duct Dia.	**HVAC Flex Duct - Maximum Duct Length in Feet**							
3”	X	X	X	X	X	X	X	X
4”	56	4	X	X	X	X	X	X
5”	NL	81	42	16	2	X	X	X
6”	NL	NL	158	91	55	18	1	X
7”	NL	NL	NL	NL	161	78	40	19
8”	NL	NL	NL	NL	NL	189	111	69

NL: No limit;
X: not allowed
Table assumes no elbows. Deduct 15 ft from allowable duct length for each elbow.

APPENDIX 3: N-VALUES FOR CFMN-TO-CFM$_{50}$ CONVERSION

Choose appropriate N-value based on location and number of stories above grade for the house. Multiply by the N-value to change CFMn (natural cubic feet per minute) to CFM50 (cubic feet per minute at 50 Pascals blower door measurement). Divide CFM50 by N to get CFMn.

Table 13 - N-Values for Locations in the BPA Region

City/Station	State	1	1.5	2	2.5	3
Boise Air Terminal	Idaho	23	20	18	17	16
Lewiston Nez Perce	Idaho	28	25	23	21	20
Pocatello Regional AP	Idaho	21	18	17	16	15
Billings	Montana	18	16	15	14	13
Cut Bank	Montana	19	17	15	14	14
Dillon	Montana	22	19	18	17	16
Great Falls	Montana	19	17	15	14	14
Helena	Montana	22	20	18	17	16
Lewiston	Montana	22	19	18	17	16
Missoula International AP	Montana	25	22	20	19	18
Astoria Regional Airport	Oregon	23	21	19	18	17
Medford Rogue Valley	Oregon	30	26	24	22	21
North Bend Muni	Oregon	22	19	18	17	16
Portland International AP	Oregon	26	23	21	20	19
Redmond Roberts Field	Oregon	25	22	20	19	18
Salem McNary Field	Oregon	25	22	20	19	18
Olympia Airport	Washington	26	23	21	19	18
Seattle Boeing Field	Washington	23	21	19	18	17
Spokane International AP	Washington	23	21	19	18	17
Yakima Air Terminal	Washington	24	22	20	19	18

APPENDIX 4: GLOSSARY

Accessible - The characteristic to describe a building cavity or space within a building that workers can work within with satisfactory safety and effectiveness.

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 primary air barrier is the most effective of a series of air barriers.

Air changes per hour at 50 Pascals (ACH50) - The number of times that the complete volume of a home is exchanged for outside air each hour, when a blower door depressurizes the home to 50 Pascals.

Air exchange - The total building air exchanged with the outdoors through air leakage and ventilation.

Air-impermeable insulation - An insulation like high-density spray polyurethane foam that is a good air barrier compared to fibrous insulations.

Appliance - Any device powered by electricity or gas designed for household use. A typical appliance is a refrigerator.

Attic - The unfinished space between the ceiling assembly of the top story and the roof assembly.

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

Backer rod - Polyethylene foam rope used as a backer for caulking.

Band joist - The outermost joist around the perimeter of the floor framing. See Rim joist.

Basement - The portion of a building that is partly or completely below grade.

Batt - A narrow blanket of fiberglass insulation, often 14.5 or 22.5 inches wide.

Belly return - A configuration found in some manufactured homes that uses the belly cavity as the return side of the distribution system.

Blower door - A device that consists of a fan, a removable panel, and gauges used to measure and locate air leaks.

Blown insulation - A loose-fill insulation that is blown into attics and building cavities using an insulation blowing machine.

Boot - A duct section that connects between a duct and a register.

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

Building science - Branch of science concerned with comfort, health, safety, energy efficiency, and durability of buildings.

Carbon monoxide - An odorless and poisonous gas produced by incomplete combustion.

Caulking - A mastic compound for filling joints and cracks. Installed with a caulking gun.

Cellulose insulation - Insulation, packaged in bags for blowing, made from newspaper or wood waste and treated with a fire retardant.

CFM50 - 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.

CFMn - The number of cubic feet of air flowing through a house from indoors to outdoors during typical, natural conditions. This figure can be roughly estimated using a blower door.

Chimney - A primary vertical structure containing one or more flues, for the purpose of carrying gaseous products of combustion and air from a fuel-burning appliance to the outside atmosphere.

Combustible - The rating for building materials that will burn under some conditions.

Combustion air - Air that provides oxygen for combustion.

Combustion analyzer - A device used to measure steady-state efficiency of combustion heating units.

Combustion appliance zone (CAZ) - A zone within the home that contains a combustion appliance for the purpose of space heating or water heating.

Condense - When a gas turns into a liquid as it cools, we say it condenses. Condensation is the opposite of evaporation.

Conditioned - Heated or cooled areas of a building are said to be conditioned, either intentionally or unintentionally.

Conditioned space - For energy purposes, space within a building that is provided with heating and/or cooling equipment or systems, or communicates directly with a conditioned space. For mechanical purposes, an area, room or space being heated or cooled by any equipment or appliance.

Conduction - Heat flow from molecule to molecule in a solid substance.

Confined space - A space with a volume of less than 50 cubic feet per 1,000 BTUH of the total input rating of all combustion appliances installed in that space.

Contractor - Any for-profit, not-for-profit, or government entity that provides services to the program under contract, not as a result of a grant of funds.

Convection - The transfer of heat caused by the movement of a fluid like water or air. When a fluid becomes warmer it becomes lighter and rises.

Cooling load - The maximum rate of heat removal required of an air conditioner when the outdoor temperature and humidity are at the highest expected level.

Cost-effective - Having an acceptable payback, return-on-investment, or savings-to-investment ratio.

Cubic foot per minute (cfm) - A measurement of air movement past a certain point or through a certain structure.

Density - The weight of a material divided by its volume, usually measured in pounds per cubic foot.

Dew point - The warmest temperature of an object in an environment where water condensation from the surrounding air would form on that object.

Direct vent - A combustion appliance that draws combustion air from outdoors and vents combustion products to outdoors.

Distribution system - A system of pipes or ducts used to distribute energy.

Dormer - A vertical window projecting from a roof.

Drainage plane - A space that allow water storage and drainage in a wall cavity, adjacent to or part of the weather-resistant barrier.

Drywall - Gypsum interior wallboard used to produce a smooth and level interior wall surface and to resist fire.

Eave - The part of a roof that projects beyond its supporting walls. See also soffit.

Efficiency - The ratio of output divided by input.

Energy - A quantity of heat or work.

Energy audit - The process of identifying energy conservation opportunities in buildings.

Energy consumption - The conversion or transformation of potential energy into kinetic energy for heat, light, electricity, etc.

Energy conservation - Reducing energy consumption.

Energy efficiency - Term describing how efficiently a building component uses energy.

Energy factor - The fraction of water heater input remaining in 64 gallons of hot water extracted from a water heater.

Energy-recovery ventilator - A ventilator that recovers latent and sensible energy from the exhaust air stream and imparts it to the incoming air stream.

Envelope - The building shell. The exterior walls, floor, and roof assembly of a building. Also sometimes denotes a building cavity or building assembly.

Fahrenheit - A temperature scale used in the United States and a few other countries. On the Fahrenheit scale water boils at 212°F and freezes at 32°F.

Fiberglass - A fibrous material made by spinning molten glass.

Fibrous insulation - Insulation made of mineral or cellulose fibers including fiberglass, cellulose and rock wool.

Fill tube - A plastic or metal tube used for its stiffness to blow insulation inside a building cavity.

Final inspection - An evaluation of a weatherization job after its completion.

Fire barrier - A tested building assembly, designed to contain a fire for a particular time period: typically 1-to-4 hours.

Fire stop - Framing member designed to stop the spread of fire within a wall cavity.

Firewall - A structural wall between buildings designed to prevent the spread of a fire.

Flammability - The rating for building materials that will burn readily when exposed to a flame.

Flashing - Waterproof material used to prevent leakage at intersections between the roof surface at walls or penetrations.

Flush fin - A window fin that seals to a flat exterior surface such as stucco.

Floor joists - The framing members that support the floor.

Foam board - Plastic foam insulation manufactured most commonly in 4'x8' sheets in thicknesses of 1/4” to 3".

Foam compatible adhesive - Adhesive that is manufactured for the purpose of safely adhering to foam.

Gable - The triangular section of an end wall formed by the pitch of the roof.

Gable roof - A roof shape that has a ridge at the center and slopes in two directions.

Gasket - Elastic strip that seals a joint between two materials.

Glazing - Glass installation. Pertaining to glass assemblies or windows.

Glazing compound - A flexible, putty-like material used to seal glass in its sash or frame.

Ground-moisture barrier - Most crawlspaces require ground-moisture barriers to prevent the ground from being a major cause of moisture problems. The ground under a building is the most potent source of moisture in many buildings, especially those built on crawlspaces.

Head flashing - Rigid flashing that directs water away from the top of a window.

Heat-recovery ventilator - A central ventilator that transfers heat from exhaust to intake air.

Heat transmission - Heat flow through the walls, floor, and ceiling of a building. Does not include air leakage.

Heat-transfer coefficient - The amount of heat that will flow through a square foot of building cross-section experiencing a temperature difference of 1° F. See U-factor.

Heating degree day - Each degree that the average daily temperature is below the base temperature (usually 65°F) constitutes one heating degree day.

Heating load - The maximum heating rate needed by a building during the very coldest weather.

Home Ventilating Institute - A non-profit organization that certifies ventilating products.

House pressure - The difference in pressure between the indoors and outdoors measured by a manometer.

IC-Rated - Recessed lights rated to have insulation placed in direct contact with the fixture.

Ignition barrier - A material installed to prevent another material, often plastic foam, from catching fire.

Inch of Water Column (IWC) - The pressure exerted by a column of water of 1 inch in height. See also Pascal.

Infiltration - The inflow of outdoor air into the indoors, which is accompanied by an equal outflow of air from indoors to the outdoors.

Insulated glass - Two or more glass panes spaced apart and sealed in a factory.

Insulation - Material with relatively high thermal resistance.

Intermediate zone - A zone located between the building's conditioned spaces and outdoors, like a crawlspace or attic.

International Code Council - An organization that writes and publishes building codes.

Intumescent paint - A special paint designed and manufactured to be an ignition barrier when applied to spray foam insulation.

Jamb - The side or top piece of a window or door frame.

Joist - A horizontal wood framing member that supports a floor or ceiling.

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

Kilowatt-hour (kWh) - A unit of electric energy equal to 3600 kilojoules or 3412 BTUs.

Lath - A thin strip of wood or base of metal or gypsum board serving as a support for plaster.

Living space - A space in a dwelling that is lived in or regularly occupied. This space may be conditioned or unconditioned.

Low-e - Short for low emissivity, which means the characteristic of a metallic glass coating to resist the flow of radiant heat.

Masonry - Construction of stone, brick, or concrete block.

Make-up air - Air supplied to a space to replace exhausted air.

Mastic - A thick creamy substance used to seal seams and cracks in building materials.

Manufactured home - A home built on a steel trailer chassis in a factory and delivered to the home site by a truck.

Mobile home - Same as manufactured home. Considered by the manufactured housing industry as an obsolete term.

Mortar - A mixture of sand, water, and cement used to bond bricks, stones, or blocks together.

Nailing fin - A window fin with holes for fastening to sheathing or a window buck.

Natural ventilation - Ventilation using only natural air movement, without fans.

Net free area - The area of a vent after that area has been adjusted for insect screen, louvers, and weather coverings. The net free area is always less than the actual area.

Noncombustible material - Materials that pass the test procedure for defining non-combustibility of elementary materials set forth in ASTM E 136.

Pascal - A unit of measurement of air pressure. See also Inch of Water Column.

Payback period - The number of years that an investment in energy conservation will take to repay its cost in energy savings.

Perm - A measurement of how much water vapor a material will let pass through it per unit of time.

Plate - A piece of lumber installed horizontally to which the vertical studs in a wall frame are attached.

Plenum - The piece of ductwork that connects the air handler to the main supply duct.

Polyethylene - Polymer plastic used for vapor barriers, air barriers, and foam backer rod.

Polyisocyanurate - A plastic foam insulation sold in sheets, similar in composition to polyurethane.

Polystyrene insulation - A rigid plastic foam insulation, usually white or blue in color.

Polyurethane - A versatile plastic foam insulation, usually yellow in color.

Pressure - A force encouraging flow by virtue of a difference in some condition between two areas.

Pressure pan - A device used to block a duct register, while measuring the static pressure behind it, during a blower door test.

Pressure Relief Valve - A safety component required on a boiler and water heater, designed to relieve excess pressure buildup in the tank.

Purlins - Framing members that sit on top of rafters, perpendicular to them, designed to spread support to roofing materials.

R-value - A measurement of thermal resistance.

Register - A grille covering a duct outlet.

Rafter - A beam that gives form and support to a roof.

Relative humidity - The percent of moisture absorbed in the air compared to the maximum amount possible. Air that is saturated has 100% relative humidity.

Resistance - The property of a material resisting the flow of electrical energy or heat energy.

Retrofit - An energy conservation measure that is applied to an existing building. Also means the action of improving the thermal performance or maintenance of a building.

Return air - Air circulating back to the furnace from the house, to be heated by the furnace and supplied to the rooms.

Rim joist - The outermost joist around the perimeter of the floor framing.

Rodent barrier - A covering attached to the bottom of a manufactured-home floor to exclude rodents and other pests and to prevent damage to the floor insulation.

Sash - A movable or stationary part of a window that frames a piece of glass.

Self-regulating heating cable - Heating cable which automatically adjust their power in response to ambient temperatures changes.

Sealant - Material used for sealing something so as to make it airtight or watertight. See also Caulking.

Sheathing - A structural sheeting, attached on top of the framing, underneath siding and roofing of a building.

Sheeting - Any building material used for covering a building surface.

Sill - The bottom of a window or door frame.

Sill pan - A metal or plastic pan installed on a window sill during window installation to trap water and divert it to outdoors.

Sling Psychrometer - A device holding two thermometers that is slung through the air to measure relative humidity.

Soffit - The underside of a roof overhang or a small lowered ceiling, as above cabinets or a bathtub.

Solar heat-gain coefficient (SHGC) - The ratio of solar heat gain through a window to incident solar heat. Includes both transmitted heat and absorbed and re-radiated heat.

Sone Rating – Rating of noise volume from a fan. Lower ratings equate to lower noise.

Space conditioning - Heating, cooling, or ventilation of an indoor space.

Specification - A characteristic of a material. An installation instruction. A list of characteristics or instructions.

Stack effect - The draft established in a building from air infiltrating low and exfiltrating high.

Stop - A thin trim board for windows and doors to close against or slide against.

Strike plate - The metal plate attached to the door jamb that the latch inserts into upon closing.

Stucco - Plaster applied to the building's exterior walls.

Stud - A vertical framing member used to build a wall.

Subfloor - The sheathing over the floor joists and under the flooring.

Substrate - A layer of material to which another layer is applied.

Thermal barrier - A material that protects materials behind it from reaching 250° F during a fire. Drywall is a 15-minute thermal barrier.

Thermal boundary - A line or plane where insulation and air barrier(s) exist in order to resist thermal transmission and air leakage through or within a building shell.

Thermal break - A piece of relatively low conducting material between two high conducting materials.

Thermal bridging - Rapid heat conduction resulting from direct contact between very thermally conductive materials like metal and glass.

Thermal envelope - The basement walls, exterior walls, floor, roof and any other building element that enclose conditioned spaces.

Truss - A lightweight, rigid framework designed to be stronger than a solid beam of the same weight.

U-factor - The amount of heat that will flow through a square foot of building cross-section experiencing a temperature difference of 1° F.

U-value - See U-factor. An obsolete term for U-factor.

Unconditioned space - An area within the building shell that is not intentionally heated or cooled.

Underfloor - The underside of the first floor of a building, with its floor joists and the spaces between them.

Vapor barrier - A Class I vapor retarder that resists the flow of water vapor to less than 0.1 perm.

Vapor diffusion - The flow of water vapor through a solid material.

Vapor retarder - A material that resists the flow of water vapor to less than 1.0 perm.

Ventilation - The movement of air through an area for the purpose of removing moisture, air pollution, or unwanted heat.

Volt - The energy contained in each unit of charge in joules per coulomb.

Watt - A unit of electrical power equivalent to one joule per second or 3.4 BTUH.

Watt-hour - A unit of electrical energy equivalent to 3600 joules or 3.4 BTUs.

Weatherization - The process of reducing energy consumption and increasing comfort in buildings by improving energy efficiency of the building.

Water-resistant barrier - A material that prevents water from wetting the wall assembly.

Weatherstripping - Flexible gaskets, often mounted in rigid metal strips, for limiting air leakage.

Webbing - A reinforcing fabric used with mastics and coatings to prevent patches from cracking.

Weep holes - Holes drilled for the purpose of allowing water to drain out of an area in a building where it has collected.

Wet-bulb temperature - The temperature of a dampened thermometer of a sling psychrometer used to determine relative humidity, dew point, and enthalpy.

Window buck - A wood frame inserted into a window opening to frame and fasten the window to the structure.

Window frame - The sides, top, and sill of the window which forms a box around window sashes and other components.

Work scope - The summary of energy conservation measures, materials lists and labor estimates that is prepared by an energy auditor as part of an energy audit.

Worst-case depressurization test - A safety test, performed by specific procedures, designed to assess the probability of chimney backdrafting.

Zone - A room or portion of a building separated from other rooms by an air barrier—not usually an effective air barrier.

APPENDIX 5: ACRONYMS

ACCA - Air Conditioning Contractors of America

ACH - Air Changes per Hour

ANSI - American National Standards Institute

ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASTM - American Society for Testing Materials

AWG - American Wire Gauge

BPI - Building Performance Institute

BTU - British Thermal Unit

CAZ - Combustion Appliance Zone

CFM - Cubic Feet per Minute

CFR - Code of Federal Regulations

CPD - Certified Products Database

CO - Carbon Monoxide

CPSC - Consumer Products Safety Commission

DOE - U.S. Department of Energy

DHW - Domestic Hot Water

DP - Difference in Pressure

EPA - U.S. Environment Protection Agency

ERV - Energy Recovery Ventilator

FTC - Federal Trade Commission

GFCI - Ground-Fault Circuit Interrupter

HRV - Heat Recovery Ventilator

HVAC - Heating, Ventilating, and Air-Conditioning

HUD - Housing and Urban Development

ICAT - Insulation Contact Airtight

IECC - International Energy Conservation Code

IEC - International Electrical Code

IFGC - International Fuel Gas Code

IMC - International Mechanical Code

IRC - International Residential Code

IWC - Inches of Water Column

kW - Kilowatt

kWh - Kilowatt-hour

MSDS - Material Safety Data Sheet

NAECA - National Appliance Energy Conservation Act

NFA - Net Free Area

NFPA - National Fire Protection Agency

NFRC - National Fenestration Rating Council

NIOSH - National Institute for Occupational Safety and Health

NM - Non-metallic

OSB - Oriented Strand Board

OSHA - U.S. Occupational Safety and Health Administration

PTCS - Performance Tested Comfort Systems

SHGC - Solar Heat-Gain Coefficient

SPFA - Spray Polyurethane Foam Alliance

UL - Underwriters Laboratory

UV - Ultraviolet

WRB - Water Resistive Barrier

WRT - With Reference To

APPENDIX 6: STATE BUILDING CODE DIVISIONS

Idaho Building Code Division

http://dbs.idaho.gov/Codes/faq.html

Montana Building Code Division

http://bsd.dli.mt.gov/bc/rules.asp

Oregon Building Code Division

http://www.cbs.state.or.us/bcd/programs/online_codes.html

Washington Building Code Division

https://fortress.wa.gov/ga/apps/SBCC/

www.bpa.gov

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