13. Planing a door in place.
14. Replacing door jambs and thresholds.
15. Replacing windows or doors.
16. Furnace replacements.
    a. Additionally, Level 2 containment must ALWAYS be used where any of the following is conducted (even if the activities will disturb less than the hazard levels within the Level 1 category):
17. Window replacement.
18. Demolition of painted surface areas.
19. Using any of the following: Open-flame burning or torching; machines to remove paint through high-speed operation without HEPA exhaust control; or operating a heat gun at temperatures at or above 1100 F^{O}. Note that the use of a drill, reciprocating saw, or other power tool is considered a "machine" for removing paint. As examples: Cutting an attic hatch inside the dwelling or interior drilling of holes for the installation of insulation requires level two containment.
20. There must be adequate documentation in the client file to demonstrate that lead-safe weatherization measures were performed when necessary. Documentation should include photos of the site and containment set up, as well as a listing of materials used and measures taken. Post-work inspector must also certify that LSW procedures were used and properly implemented.
21. Maine Weatherization will adhere to EPA lead safe rules as written in the "Lead; Renovation, Repair, and Painting Program" Final Rule (LRRPP Final Rule), as directed by DOE.
22. Weatherization of HUD program housing stock, including HUD Section 8, is infrequent in Maine. These units will only be weatherized if HUD will provide certification that abatement or control of any lead paint hazard has been addressed, and will agree that the local agency will not be liable for any lead hazards, provided the safe work practices generally outlined herein are employed.
23. In cases where the agency cannot safely weatherize a home due to lead paint hazards, the agency must defer the work. Such deferral will be considered by the state on a case-by-case basis. Agencies may not weatherize dwellings where there are cases of documented or suspected lead poisoning. Additionally, they shall not weatherize homes where there is an extraordinary lead paint hazard and there are no means to abate the hazard.

4.15 Moisture Remediation, Assessment, and Repairs

4.15.1 Remediation of Mold

The use of DOE funds for the removal of mold and other related biological substances is not an allowable weatherization expense. Limited water damage repairs that can be addressed by weatherization workers and correction of moisture and mold creating conditions are allowed when necessary in order to weatherize the home and to ensure the long term durability of the measures. Generally, DOE funds should not be used to test, abate, remediate, purchase

4.15.3 Mitigation of Moisture Sources

Moisture problems that might 1) result in health problems for the client, 2) damage the structure over the short or long term, or 3) diminish the effectiveness of the weatherization measures must be repaired before the weatherization job is completed. Refer to DOE WAP Notice 11-6 for allowable tasks for moisture mitigation.

1. Moisture problems can be reduced or eliminated by controlling the source of the moisture. This may involve:
    a. Installing a ground cover on a crawl space floor.
    b. Venting dryers to the outside of the building.
    c. Sealing the foundation.
    d. Providing drainage away from the foundation.
    e. Repairing the roof, flashing, gutter, or downspout.
    f. Educating the client about the sources of moisture that they are able to control.
2. Moisture problems can be reduced or eliminated by ventilating areas where excessive moisture is produced, such as bathrooms and kitchens. This should include installation of a high quality exhaust fan in the subject area, and informing the client of the related moisture issues and the proper operation and use of the fan. See Section 4.16 for exhaust fan installation guidelines.

4.15.4 Dryer Vents

1. Electric and gas dryers must be vented to the outdoors.
2. Manufactured home dryer vents must be extended through the skirting to the outdoors.
3. Rigid and smooth dryer duct without a booster fan shall be no more than 25 feet long. Reduce this maximum length by 2.5 feet for each 45-degree elbow and 5 feet for every 90-degree elbow.
4. Flexible vinyl vent pipe shall not be used.
5. Flexible metal vent pipe shall not exceed 6 feet in length.
6. Gas dryer vent pipe should not be installed with sheet metal screws or other intrusive fasteners that will collect lint (according to NFPA 54).
7. All dryer ducts shall terminate outdoors. The termination shall have a back-draft damper and a grille or louvers to keep out vermin.

4.16 Ventilation Systems for Acceptable Indoor Air Quality

ASRHAE 62.2-- 2016, *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*, shall be used for the installation of ventilation systems, both local ventilation and whole-building ventilation. This ASHRAE standard is for buildings of three stories or fewer. If the building under

6.2.2 Blower Door Use Requirements

1. Pre- and post-weatherization CFM_{50} measurements must be completed on each unit and documented in the client file. A single-point CFM_{50} blower door measurement is preferred over the multi-point, computer-derived method. See Section 5.1, or manufacturer's manual for proper blower door setup and use.
    a. Pre- and post-weatherization blower door tests may be waived by MaineHousing with documentation due to the following:
        i. Additional problems may be created in the unit due to a lack of structural integrity.
        ii. Solid-fuel combustion appliances are operating. Attempts must be made to have the client shut down a solid-fuel burning appliance approximately twenty-four hours before the pre-weatherization energy audit is conducted. Similar attempts must be made before the post-weatherization inspection.
        iii. Suspected friable asbestos-containing material may be disturbed.
        iv. Other documented extenuating circumstances.
2. Blower door testing shall be completed periodically during air-leakage reduction work as part of blower-door-guided air sealing.

6.3 Penetrations and Holes

6.3.1 Common Penetrations and Holes

1. All penetrations through the exterior sidewalls of a dwelling that require sealing must be sealed from the interior with the exception of:
    a. Foundations, which may be sealed from either the interior or exterior.
    b. Any hole or penetration requiring sealing to keep out rain or snow.
2. Before blown insulation is installed, all obvious leaks should be sealed. These leaks might include, but are not limited to:
    a. Open top plates (usually in balloon frame or manufactured housing).
    b. Chases around masonry and metal chimneys.
    c. Chases around plumbing stacks.
    d. Missing window sashes or lights.
    e. Doors misaligned in their frames.
    f. Missing drywall or other interior finish materials.
    g. Missing or misaligned attic doors or hatches.
    h. Missing or misaligned bulkhead doors in basements.

c. Sealing the air conditioner unit from the interior.

6.5 Zone Pressure Diagnostics

1. Zone Pressure Diagnostics (ZPD) testing can be an effective tool to assist in determining the location of pressure boundaries of the dwelling, the effectiveness of air sealing measures, and indoor air quality concerns. Please refer to Section 5.9 for the details of ZPD procedures.

    a. ZPD testing can be useful to verify the effectiveness of attic air sealing and therefore is a recommended tool.

        i. Attics may be tested using the add-a-hole method to assess leakage between the attic and conditioned living space. This test is most effective when conducted prior to, and then after, performing air sealing measures in order to determine the quality and completeness of the air leakage and bypass sealing

    b. Determining the amount of air leakage between an attached or tuck-under garage, and then confirming air leakage has been reduced to an acceptable level by air sealing measures is important to the client's health and safety.

        i. Post-weatherization air leakage between the house and garage (house-to-zone, open-a-door ZPD method) can be determined using either the MaineHousing Zone Pressure-Series Leakage Diagnostics worksheet or Residential Energy Dynamics, LLC free software, RED Calc Free ZPD Zone Pressure Diagnostics tool, available on line The ZPD garage to house leakage goal is 200 CFM_{50} or less.

        ii. Whatever air sealing methods are used, the Inspector shall use smoke and visual evaluation to confirm the living space is adequately separated from the garage.

        iii. The air leakage status between the house and garage will ~~must~~ be documented in the client file.

2. Basements and crawl spaces should be tested using a monometer, noting - pressure - differences when the housing construction type or the air leakage rate indicates that there may be hidden air leakage into or from the basement or crawl space, or air quality problems are resulting from air leakage from a basement or crawl space. This test should be conducted prior to, and after, installing air sealing measures in order to determine the quality and completeness of the air sealing. In addition, this test can help determine the appropriate location of the pressure and thermal boundaries. Please refer to Section 5.9 for instructions.

7 Insulation Requirements

"Borate-only" grade cellulose is the approved insulation for the Maine Weatherization Program. "Ammonium-sulfate-and-boric-acid grade cellulose is not approved. The Installer shall provide documentation to the client - of the insulation installed - in accordance with the Maine Weatherization Field Guide. Documentation requirements are specific to each insulation type. This section applies only to site built dwellings. Manufactured homes are covered in Chapter 9.

7.1 Electrical Safeguards

1. Correct electrical problems such as unsafe wiring, open junction boxes, or other electrical code violations prior to performing any other work in the -home.
2. All visible electrical junction boxes shall be covered with an appropriate junction box cover.
3. All electrical boxes/fixtures shall be flagged for identification above any installed insulation. For two part spray foam insulation, all electrical boxes will be covered with masking tape to prevent foam insulation from entering boxes. All electrical boxes will be accessible after spray foam installation.
4. All non-Type IC electrical fixtures shall be blocked with rigid material fastened in place to ensure a minimum insulation clearance of 3 inches and a maximum clearance of 6 inches. Examples include prefabricated Insullite boxes or on site-built boxes constructed of sheet rock.
    a. Exceptions to this rule include Type IC (insulation contact) recessed lights and light/fan combinations, and closed junction boxes.
5. It is permissible to remove recessed light fixtures with client permission if this is the most practical method of air sealing. Be certain to observe all appropriate codes. It might be less costly to replace existing non-Type IC fixtures with Type IC fixtures than removing the recessed lighting altogether.
6. Knob-and-tube wiring:
    a. MaineHousing requires that knob-and-tube wiring be deactivated before installing insulation. If the cost of doing so, when added to the installation cost of the insulation- results in an SIR - of one or greater, it may be charged as an Incidental Repair to the insulation measure. Minor upgrades or repairs necessary for weatherization measures may be charged to Health & Safety. If the additional costs of deactivation results in an SIR less than 1.00, than the Deferral of Services Form shall be completed.
    b. If knob-and-tube wiring has been deactivated and the dwelling has been rewired with BX, NM, or other approved electrical cable, the attic may be insulated over the inactive knob-and-tube.

7.2 Attic and Roof Insulation

7.2.1 Inspection, Preparation, and Repairs

1. Prior to installing insulation, a thorough inspection of the attic area must be performed.

6. Requirements for furnaces installed in attics:
    a. Attic furnace blocking must be installed to ensure a minimum free air clearance of 18 inches, but not more than 24 inches.
    b. If there is a work platform for an attic furnace, or if one is installed as part of the weatherization work, 30 inches of clearance adjacent to the furnace controls must be provided.
    c. Attic furnaces must be checked after adding attic insulation to ensure they are free of insulation and operate properly.

7.2.6 Installation Methods for Attic Insulation

1. Locate and seal attic thermal bypasses, chases, and open-topped partition walls. Remove enough of any existing flooring so that a thorough inspection for, and repair of, attic bypasses is possible. Properly treat ceiling height changes and stairwells as necessary to stop air leakage. Seal knee wall floor cavities. Make sure bypasses are completely sealed before installing any insulation.
2. Attic insulation must completely cover conditioned spaces and must be installed at an even depth, except where physical constraints exist.
3. Insulation must be installed to the outside edge of the top plate of an exterior wall.
4. Insulation may not cover functional soffits vents or fill the eave/soffit area. Added insulation shall not restrict the airflow through vents.
5. Insulation must be installed according to the manufacturer's specifications for coverage and R-value.
6. Attic to house pressure can be tested using a simple manometer pressure test between the attic and conditioned living space, when the housing construction type or the blower door air leakage rate indicates there may be hidden air leaks or bypasses into the attic. Prior to testing, observe and note any visible openings from the attic to the outside, e.g. gable or soffit vents. While these may remain for both pre and post testing of the installation of the air sealing measures the auditor has noted on the work order, the difference in the pre and post pressure readings will be the result of only the air sealing of the attic plane and will help determine the quality and completeness of the air leakage and bypass air sealing Please refer to Section 5.9 for instructions.
7. If the installation of cellulose insulation on top of existing batt or blanket insulation is appropriate, cut and remove or roll back 1 to 2 feet of this insulation at the eave sides of the house so that the top surface of the ceiling material is exposed. If the finished ceiling material is strapped perpendicularly to the joists, remove all of the batt insulation from the joist bays that border the gable ends before insulating with blown cellulose.
8. It is preferred that cellulose insulation be installed in the attics of site-built homes.

7.2.7 Insulation Coverage and Density

1. Insulate uninsulated open-joist attics in order to achieve the greatest SIR value.
    a. Insulation installers shall install a minimum of one depth gauge for every 300 square feet of attic area.
    b. A verification label is to be posted by the installer inside the attic near the attic access in each dwelling unit. This label shall include:
        i. Installer's business name.
        ii. Date of installation.
        iii. Insulation type.
        iv. Installed and Settled insulation depth.
        v. Number of bags installed in accordance with Manufacturer specifications (SWS 4.1005.2d)
2. For attics with existing insulation, measure the density of the insulation in a selected test area before beginning the major installation. The density of blown insulation within enclosed cavities must be within the range of the values listed under #3 and #4 below.
3. Insulate enclosed areas (under floors and behind slopes and knee wall cavities, etc.) to the following density levels, as long as interior finish materials are able to withstand the pressure without damage:
    a. Blown cellulose at a density of 3.25 to 3.75 lb./ft^3.
    b. Blown fiberglass at a density of 1.6 lb./ft^3
4. Insulate knee wall cavities as follows:
    a. Blown cellulose at a density of 3.25 to 3.75 lb./ft^3.
    b. Blown fiberglass at a density of 1.6 lb./ft^3.
    c. Fiberglass batts to an insulating value of R-19.
5. Where feasible, densely packing cellulose insulation with an appropriate hose or tube is the preferred method in attics.
6. Calculating the number of bags using the manufacturer's coverage chart is the preferred method for determining the proper amount of material to be installed into an attic area at a given R-value.
7. Where the combined material and labor costs can be reduced, it is preferred that dropped soffits and similar construction details be filled with cellulose insulation.
8. When a vapor barrier is installed with the insulation, the barrier should be installed on the warm side of the insulation, but never more than one-third of the R-value away from the warm-side surface.

7.2.8 Vaulted or Sloped Ceiling/Roof Cavities

1. A vaulted ceiling or sloped ceiling/roof cavities shall be insulated to a value of at least R-19 whenever possible. If it is not possible to insulate to R-19, the reason must be documented in the client file.
2. If batt insulation is used, the vapor retarder should always face the conditioned building space. If this vapor retarder faces a habitable space, the vapor retarder must be covered with a 15-minute fire-rated material, such as ½ inch drywall taped and mudded once, or ¾ inch of wood.
3. If cellulose insulation is used, the cellulose shall be dense packed in the vaulted or sloped ceiling/roof cavities.

7.2.9 Enclosed Ceiling/Floor Cavities

When insulating enclosed ceiling cavities, it is preferred that insulation be installed in the rafter cavities from the attic, through the eave or from the interior of the home, rather than through the roofing material.

7.2.10 Storage Space

1. Where attic space is being used for storage, agencies, or contractors should request the client remove storage items from the area.
2. In cases where the client is physically unable to perform this task and is unable to solicit help from a family member or friend, agencies and contractors should include the removal of items in the cost-effective analysis of installing insulation, and proceed with the measure if it is cost-effective (if the job has an overall savings-to-investment ratio of 1.00 or greater).

7.2.11 Ductwork Insulation

1. Ductwork must be sealed appropriately with the proper materials (duct mastic) before insulation is installed. Refer to Section 2.1.4 for instructions.
2. When working ducts are located in an unconditioned attic, install a minimum of R-8 (preferably R-11 or greater, if possible) on ducts and plenums. It is preferred that attic ducts be draped with unfaced blanket insulation and blown over with loose fill insulation to at least the depth of the surrounding insulation. If faced duct insulation is installed, it is preferred that the facing be to the outside.
3. A minimum of 6 inches of clearance between duct insulation and heat sources must be maintained, unless the insulation material is rated for closer proximity.

7.2.12 Drill-and-Blow Patching

If a drill-and-blow method is used for installing floor or ceiling insulation, holes must be properly plugged, secured with adhesives, and sealed.

3. When using blown fiberglass, install at a density of 1.6 lb./ft^3.
4. Contractors must warranty wall insulation work for at least one year against voids of more than 5 percent.

7.3.11 Plugs and Patching

1. Where possible, remove the exterior lap siding and drill the sheathing and/or sub-siding for the installation of insulation. Holes in the sub-siding must be patched. Various materials may be used for this patching, including wood plugs, plastic plugs, or spray foam insulation. If installing from the interior, all drilled holes must be sealed appropriately: plugged and caulked if being covered with chair rail, or, if left exposed, plugged and resurfaced to industry standards with joint compound, and free of drying cracks. Lead-safe weatherization practices must be used.
2. If there is no other way of installing insulation in a wall other than face drilling and plugging the exposed drill holes, first obtain approval in writing from:
    a. An appropriate energy auditor at the representative weatherization agency, and
    b. The owner of the dwelling.
3. Plugs that are compatible with the siding or wall type must be used to fill and cover the exposed surface that has been drilled.
4. Exposed plugs must be sealed tightly, glued, and primed. Painting and texturing to match the plugs to the surrounding wall is allowed, but painting or texturing the entire wall is not.
5. Any wood that is replaced as a result of the weatherization work and that is exposed to the weather must be primed.
6. Stucco-sided dwellings may be insulated from the exterior or the interior. If insulated from the exterior, the stucco patch must match the existing stucco in texture and color.

7.3.12 Brick Siding

1. Interior drill and blow techniques are required for homes with brick veneer siding.
2. Ensure that cellulose insulation is never installed in contact with masonry materials.

7.3.13 Quality Control

1. A final inspection to assess quality and quantity of wall insulation must be performed by the agency. This inspection can be performed by using a bore scope, removing interior outlet and switch plates, using an infrared camera, or other acceptable inspection techniques.
2. When conditions permit, infrared scanning must be used as a quality control tool to check wall insulation work and identify areas of excessive air leakage. The infrared scanning device is a very useful tool for finding air leaks when used in conjunction with a blower door. Agencies and contractors are advised to use infrared scanning equipment.

7.4 Foundation Insulation

This section addresses rim joist insulation, basement wall insulation, and crawl space wall insulation.

7.4.1 Inspection, Preparation, and Repairs

1. An inspection from the interior and exterior of the home shall be performed prior to installing insulation. This inspection should identify all potential hazards and needed repairs and shall include the following:
    a. Building construction details.
    b. Foundation type and condition.
    c. The location of electrical, gas, oil, cable and phone lines.
    d. Plumbing pipes.
    e. Existing moisture and drainage problems.
    f. Existing structural problems.
2. An inspection from the interior of the home shall include an examination of the following:
    a. Interior foundation wall type and condition.
    b. Any knob-and-tube wiring.
    c. Electrical and plumbing utilities.
    d. Moisture problems.
3. Make any necessary repairs before installing insulation.

7.4.2 Moisture Inspection and Repair

1. All dwellings must be inspected for problems associated with excess moisture.
2. Identification of potential moisture problems shall be documented in the client file. If excessive moisture is found and determined that mitigation is beyond the scope of the weatherization program, deferral of services is required.
3. Repair any moisture problems that will degrade or diminish the effectiveness of weatherization measures.
    a. In crawl spaces, whenever conditions warrant, install a moisture barrier on the floor unless conditions do not allow. This polyethylene barrier should overlap at least 12 inches at the joints, and extend 6 inches up the crawl space wall, and be permanently fastened and air sealed on all sides and around columns and piers. When ground moisture barrier is installed on sloping ground, or accessed for routine maintenance or storage it will be fastened to the ground with durable fasteners or ballast(s)

4. If the crawl space area has 18 inches of clearance or more between the crawl space floor and ceiling, a moisture barrier must be installed unless there are substantial reasons not to. If a moisture barrier is not installed, the reasons must be included in the client file. Note: If the entire dirt floor is not accessible, cover as much as possible.
5. For basements with dirt floors, whenever feasible, install a non-skid moisture barrier on the floor for walk-ways and 6-mil polyethylene over other areas. This polyethylene barrier should overlap at least twelve inches at the joints, extend six inches up the basement wall and be permanently fastened and air sealed. Three-foot-wide rubber roofing (EPDM) or rolled roofing qualifies as non-skid moisture barriers.

7.4.3 Wall Moisture Barrier

If there is evidence of water leaks or moisture coming through the foundation wall from the exterior, a moisture barrier must be permanently attached and air sealed to the sill plate in a manner that drains the moisture behind the insulation, and covers the insulated section of the foundation or crawl space wall.

7.4.4 Treatment of Other Hazards

1. Use appropriate personal protective equipment and work practices in the presence of animal or insect hazards. Ensure personal safety during work, and refer to the postponement of service policy in Section 4.6.
2. Repair any rotted, broken, or damaged structural components.

7.4.5 Defining the Thermal/Pressure Boundary

1. If the basement or crawl space houses a heating system or other appliance, it should be treated as a conditioned area (within the thermal/pressure envelope). In this case – the most common in Maine – the basement or crawl space walls are part of the boundary of the thermal/pressure envelope. Therefore, it is preferred to air seal and insulate the basement or crawl space walls because this strategy encloses the furnace, ducts, pipes, water heater, and other appliances within the conditioned envelope. In such cases, the basement or crawl space walls should be sealed, as necessary, before any insulation is installed on these surfaces.
2. If a basement or crawl space is defined as part of the boundary of the conditioned envelope, the pre- and post-weatherization blower door tests shall include these areas. In these cases, the pre- and post-weatherization blower door tests shall be done with the basement door open. These results should be documented on the appropriate field form, noting that the blower door test results include the basement and/or crawl space areas.
3. Basements and crawl spaces should be tested using a monometer, noting - pressure - differences when the housing construction type or the air leakage rate indicates that there may be hidden air leakage into or from the basement or crawl space, or air quality problems are resulting from air leakage from a basement or crawl space. This test should be conducted prior to, and then after, installing insulation in order to determine the quality and completeness of the sealing. In addition, this test can help determine the

7.4.9.2 Exterior-wall installation:

Foundation insulation may be installed on the exterior, but this requires digging a 1-foot deep trench around the foundation. If this method is used, the rigid insulation must be extruded polystyrene at least 1 inch thick and R-5 and it must be protected from sunlight and exterior physical damage by an appropriate rigid material.

7.10 Crawl space Insulation, Additional Details

1. MaineHousing recommends including crawl spaces beneath conditioned living spaces within the thermal/pressure envelope. Crawl spaces beneath unconditioned living spaces may be left unconditioned and separated from an adjoining conditioned basement with suitable materials.
2. Seal all direct air leaks into the crawl space.
3. Seal all bypasses and chases into and through the conditioned areas of the house.
4. Route any exhaust fans to the outside, using dampened vents, smoothbore rigid pipe, and an appropriate termination fixture.
5. Install perimeter insulation from the rim or band joists to the crawl space floor. Suitable materials include double-faced vinyl insulation, rigid plastic insulation and 2 part spray foam. The crawl space wall insulation shall extend downward to:
    a. A distance that is 2 feet below the exterior grade, or
    b. The crawl space floor, and then horizontally across the floor for 2 feet, whichever is appropriate.
    c. Mechanically fasten the insulation to the sill plate and seal all joints with tape.

7.5 Floor Insulation

7.5.1 Inspection, Preparation, and Repairs

Precautions must be taken to ensure adequate combustion air is being supplied, through non-operable vents, for combustion appliances in crawl spaces or basements.

7.5.2 Moisture Inspection and Repairs

1. All units must be inspected for problems associated with excess moisture.
2. If floor insulation is installed over a crawl space, the crawl space floor shall be covered with a moisture barrier when conditions warrant. This barrier must be lapped at least 12 inches at the joints, extend up the crawl space wall 6 inches, and be permanently fastened and air sealed.
3. Identification of potential and existing moisture problems shall be documented in the client file.
4. Address and/or repair any moisture problems that will degrade or diminish the effectiveness of weatherization measures as allowed under program guidelines. Some

problems may be beyond the scope of weatherization; refer to Chapter 4, Health and Safety Requirements, for guidance.

7.5.3 Treatment of Other Hazards

1. Use appropriate personal protective equipment and work practices in the presence of animal or insect hazards. Ensure personal safety during work.
2. Repair any rotted, broken, or damaged structural components as allowed under program guidelines. Some problems may be beyond the scope of weatherization; refer to Chapter 4, Health and Safety Requirements, for guidance.

7.5.4 Defining the Thermal/Pressure Boundary

Please refer to Section 7.4.5.

7.5.5 Installation Methods for Floor Insulation

1. Installed insulation must be a minimum of R-38 in Aroostook county and R-30 in all other counties, unless a different level of insulation will achieve a higher SIR value (cannot be less than R-19). Once air sealing of bypasses and penetrations have been completed, the insulation should be installed without voids or gaps between the insulation and the bottom of the floor deck. Fit insulation tightly around cross bracing and any obstructions.
2. Floor insulation other than two-part spray foam must be fastened securely in place with wire fasteners, nylon mesh, or -other appropriate methods. Friction fitting or stapling floor insulation is not considered an appropriate method for securing the material.
    a. Do not support insulation with Tyvek, Typar, or other house wrap stapled to the bottom edges of the joists.
    b. Do not use chicken wire or other metal mesh to support floor insulation.
3. Install insulation so that it is in contact with the underside of the subfloor above.
4. Faced fiberglass insulation must have the facing upward toward the heated area.
5. Ensure that floor insulation is in direct contact with the rim or band joints. If the dwelling is balloon framed, air seal the bottom of the stud cavities prior to installing the insulation.
6. Fiberglass insulation installed as a weatherization measure must not be left exposed to habitable spaces.

7.5.6 Materials

1. Fiberglass insulation, faced or unfaced, rigid plastic insulation and 2-part spray foam are suitable insulation - materials for floors.
2. Double-faced vinyl insulation shall not be used for floor insulation.

7.5.7 Insulation Coverage

1. Floor insulation shall be installed according to manufacturer's instructions.
2. Floor insulation must be installed in a manner that provides as continuous a thermal boundary as possible.
3. Installed floor insulation must not be excessively compressed.

7.5.8 Storage Space

1. Where the basement or crawl space is being used for storage, agency personnel or the contractor should request the client remove storage items from the weatherization work area.
2. In cases where the client is physically unable to perform this task, the removal of items should be included in the savings-to-investment analysis of installing insulation, and the removal should go forward if it is cost-effective (if it has a savings-to-investment ratio of 1.00 or greater).

7.5.9 Ducts and Pipes

1. When floor insulation is installed, ductwork below the floor insulation must be appropriately sealed and insulated. Please refer to Section 2.1.5 for instructions.
2. When floor insulation is installed, any water pipe that is susceptible to freezing and all furnace supply and return ducts below the insulation must be insulated as part of the floor insulation measure. Please refer to Section 2.2.1.
3. Do not insulate over pumps, valves, pressure relief devices, or vents; do not insulate over heat tape unless the manufacturer's specification indicates that such installation is safe.

7.5.10 Crawl space Ventilation

1. If the crawl space walls or ceiling are insulated and a moisture barrier covers the crawl space floor, MaineHousing recommends the crawl space shall not be vented to the outdoors. Energy auditors shall determine that appropriate application on a case-by-case basis and document in the client file.
2. If a moisture barrier cannot be installed, the crawl space must be vented. If a moisture barrier cannot be installed, the reason shall be documented in the client file.
    a. If the energy auditor determines crawl space vents are required, the vents must provide 1 square foot of net free vent area for every 1,500 square feet of crawl space ground area if there is a 6-mil polyethylene ground cover, or 1 square foot of net free vent area for every 150 square feet of crawl space ground area if a ground cover cannot be installed.
    b. Crawl space vents shall be louvered and screened or otherwise designed to prevent the entry of snow, rain, animals, and insects into the building.

c. If operable crawl space vents are installed, the client must be informed of the benefits of closing the vents in winter and opening the vents in summer.

3. If there are more existing vents than needed, it is preferred that surplus vents be closed off with removable rigid insulation. Where possible, close off vents on the windward side of the crawl space.

   a. Do not close off or restrict combustion air vents.

8. Window and Door Repairs and Replacements

8.4 Primary Windows

8.4.1 Window Assessment

1. All existing egress windows must remain operable.
2. Non-operable, non-egress windows may be permanently sealed.

8.4.2 Window Repairs

1. When feasible, windows must be repaired, rather than replaced.
2. Replace missing, broken, or severely cracked panes.
3. Window glazing compound shall only be replaced if the existing glazing is deteriorated to the degree that the window glass is in jeopardy of falling out of the sash

8.4.3 Window Air Leakage

Window tightening measures such as caulking, weather-stripping, ACPs, and window locks can be installed if cost-effective based on the approved MaineHousing energy audit. Measures shall be installed from highest SIR to lowest.

8.4.4 Window Replacement

1. Window replacements must be based primarily on an energy-conservation and be justified by reduction in air infiltration and an increase in R-value, resulting in an SIR of 1.0 or greater.
2. The installation of replacement windows must meet applicable building codes.

8.5 Storm Windows and Insulation Systems

8.5.1 Interior Storm Windows (ACPs)

1. Interior storm windows (ACP's) can be installed - whenever feasible, - cost effective and can be justified by an SIR greater than one for air infiltration (as determined by the approved MaineHousing energy audit).
2. A ½- to 2-inch air space between the prime window and the installed storm window is preferred.
3. Allowable storm windows include:
    a. Rigid-framed, single- and double-strength glass.
    b. Rigid- and flexible-framed Plexiglas.
    c. Framed and unframed plastic "kits" with a minimum thickness of 6 mils.

4. Repairs to prime windows must be done to keep moisture out before an interior storm window may be installed over the prime window.
5. Storm windows must be securely fastened in place, installed straight, plumb, and level, and without distortion.
6. Metal storm windows should not come in contact with frames or fasteners constructed of dissimilar metals.
7. Installed storm windows in kitchens, baths, and other high moisture areas must be operable if they provide the only source of ventilation into the space.
8. Operable storm windows must move freely.

8.5.2 Movable Window Insulation Systems

1. Movable window insulation systems are only allowed when:
    a. The systems are determined to be cost-effective by the approved MaineHousing energy audit;
    b. For technical reasons, no interior or exterior storm windows can be installed;
    c. All other weatherization measures with higher SIR values already exist or have been installed, and;
    d. The client has been educated by weatherization personnel in the operation of the movable insulation system.

8.5.3 Non-Allowable Window Materials

Tinted window films, all sun shields, and heat reflective materials are not allowed.

8.6 Doors

8.6.1 Door Assessment

Door assessment shall comprise of all doors associated with the thermal boundary of the home.

1. Doors must be assessed for needed repairs for air leaks.
2. All existing egress doors must remain operable.
3. Non-operable doors may be sealed against air leakage.

8.6.2 Door Repairs

1. When feasible, a door must be repaired rather than replaced.
2. Inoperable egress doors do not have to be made operable, unless performing weatherization measures to the door.

4. *Limit switch:* Gravity furnaces must be equipped with a working high limit switch that shuts the fuel supply off at approximately 250^{o}F.

5. *Spillage:* All furnaces must be properly vented. Per the BPI 1200 Standard, the acceptable limit for spillage in a warm vent appliance is two inutes after firing, and for a cold vent appliance, five minutes after firing. All water heaters shall be considered warm vent. The flue must not be clogged, disconnected, or rusted to the point where it leaks. All furnaces, with the exception of direct-vent units, must be tested with worst-case depressurization test procedures (see Section 5.7).

6. *Filter:* If the manufacturer intended that the appliance have a filter, it should be checked for cleanliness. If a filter was not intended by the manufacturer, one shall not be installed.

7. *Other cleaning:* Other necessary cleaning should be done, including air intakes, burners, furnace controls, heat exchangers, the blower compartment and return air plenum, registers, and grilles.

8. Btu/hour Input for gas freestanding, wall, and floor units: Actual appliance output must be determined and fall within a range of plus or minus 20 percent of the required heat output for the heated space in its post-weatherized condition. If the existing appliance output rating falls outside of this range, replacement for reasons of health and safety should be considered.

9. *Replacement units:* Any replacement unit must not be sized by more than 115 percent of the total load; however the next available size may be used.

10.3.3 Manufactured Home Sealed Combustion Furnaces

All sealed combustion manufactured home furnaces should conform to the following:

1. *Gas-fired unit requirements:*

a. *Gas Leaks*: When testing for gas leaks, hold the leak detector probe just below a propane gas line or just above a natural gas line. If a leak is detected, verify with soap solution. All identified gas leaks should be reported to the client and referred to appropriate persons for repair or replacement.

b. *Flexible gas lines* must be replaced under the following conditions:

   i. The line is badly kinked, corroded or shows signs of physical wear.

   ii. The line connection is the soldered, two-piece type.

   iii. The line was manufactured before 1973. Sometimes there is a metal ring on the flexible line that is dated. If there is no dated metal ring, use one of the first two criteria listed just above.

c. *Cleaning and tuning:* All gas-fired units must be cleaned and tuned once every 2 to 3 years. Follow MaineHousing's CTE policy (refer to Section 10 Introduction)

and educate the client as to the importance of having this service performed regularly.

2. *Oil-fired unit requirements:*

a. *Oil storage and piping*: Check the oil tank and piping for leaks and compliance with all appropriate codes.

b. *Cleaning and tuning:* All oil-fired units should be cleaned and tuned annually. Follow MaineHousing's CTE policy (refer to Section 10 Introduction) and educate the client as to the importance of having this service performed regularly.

3. *Thermostat:* The furnace must have a thermostat in working condition that is compatible with the control circuit type (24 volt vs. millivolt). Thermostats containing mercury switches that are in need of replacement shall be removed, replaced and disposed of in accordance with EPA regulations10. For 24-volt systems, the anticipator on the thermostat should be set equal to the measured gas valve circuit amperage. Those appliances not equipped with a thermostatic control should not have one added. Non-electric setback thermostats with an adjustable anticipator may be installed under the following conditions:

a. The client's lifestyle indicates potential for energy savings;

b. The client is receptive to the installation; and

c. The client is provided appropriate education on the operation of the thermostat.

It is preferred that manufactured home thermostats be located on an interior wall.

4. *Fan-on/fan-off:* Ideally, the fan-off temperature is between 95^{o} and 100^{o}F, but never below 80^{o}F. The fan-on target range is between the fan-off setting and 130^{o}F, but must never exceed 140^{o}F. In addition, all appliances that are not direct vent combustion-type and have inaccessible flue pipes must have a spillage check done to verify that there is no significant spillage.

5. *Limit switch:* This switch should shut the gas valve off at approximately 200^{o}F, where appropriate.

6. *Temperature-rise test:* Must be checked on all furnaces. Temperature rise should fall within the manufacturer's recommended temperature range (see name plate on appliance). If this information is not available, the temperature rise should fall within a 40^{o} to 80^{o} F range. The furnace must not cycle on the high-limit switch. See Section 5.6 for instructions on measuring temperature rise; temperature rise measurement testing must be conducted by the CAA Energy Auditor and QCI, pre and post weatherization

8. *Ductwork:* For a discussion of duct leakage measurements and standards, follow the instructions in Section 2.1.3. For ductwork sealing and insulation, see Section 2.1.

[10] 40 CFR 271.13

9. *Filter:* A clean filter should be installed in a location where the client can locate it for the purpose of replacing or cleaning it. No filters shall be installed on furnaces that do not have separate heat exchanger/blower compartments (International and Intertherm brands).

10. *Blower or air handler:* The air handler/blower should be visually inspected and cleaned if necessary. The motor and blower must be oiled (where applicable).

11. *Other cleaning:* Other necessary cleaning should be done, including air intakes, burners, furnace controls, heat exchangers, the blower compartment and return air plenum, registers, and grilles.

12. *Non-sealed combustion furnaces:* These units should be replaced with sealed combustion furnaces.

13. *Replacement units:* Any replacement unit must not be sized by more than 115 percent of the total load; however the next available size may be used.

10.3.4 Boilers

A boiler efficiency safety check should be conducted on all operable natural gas- or propane-fired heating systems. Tests should be performed on all oil-fired systems that have a smoke reading of 2 or less. Modifications and repairs, when possible, should meet the following specifications (applicable to type) and/or comply with the follow-up procedures. The qualified technician must document each situation in which any of the following specifications cannot be met.

1. *Gas-fired unit requirements:*

a. *Gas Leaks:* When testing for gas leaks, hold the leak detector probe just below a propane gas line or just above a natural gas line. If a leak is detected, verify with soap solution. All identified gas leaks should be reported to the client and referred to appropriate persons for repair or replacement.

b. *Flexible gas lines* must be replaced under the following conditions:

i. The line is badly kinked, corroded or shows signs of physical wear.

ii. The line connection is the soldered, two-piece type.

iii. The line was manufactured before 1973. Sometimes there is a metal ring on the flexible line that is dated. If there is no dated metal ring, use one of the first two criteria listed just above.

2. *Cleaning and tuning:* All gas-fired units should be cleaned and tuned once every 2 to 3 years. Follow MaineHousing's CTE policy (refer to Section 10 Introduction) and educate the client as to the importance of having this service performed regularly. *Oil-fired unit requirements:*

a. *Oil storage and piping:* Check the oil tank and piping for leaks and compliance with all appropriate codes.

b. *Cleaning and tuning:* All oil-fired units should be cleaned and tuned annually. Follow MaineHousing's CTE policy (refer to Section 10 Introduction) and educate the client as to the importance of having this service performed regularly.

*C*onstant temperature boilers in single-family residences should be converted to cold-start type boilers whenever feasible.

3. *Thermostat:* The boiler must have a thermostat in working condition that is compatible with the control circuit type (24 volt vs. millivolt). Thermostats containing mercury switches that are in need of replacement shall be removed, replaced and disposed of in accordance with EPA regulations[11]. For 24-volt systems, the anticipator on the thermostat should be set equal to the measured control circuit amperage. Non-electric setback thermostats with an adjustable anticipator may be installed under the following conditions:

   a. The client's lifestyle indicates potential for energy savings;

   b. The client is receptive to the installation; and

   c. The client is provided appropriate education on the operation of the thermostat.

4. *Zone values:* Malfunctioning zone valves in intentionally heated areas must be made operable, when feasible.

5. *Aquastat operation:* The aquastat control settings should be within the range of the manufacturer's recommendations.

6. *Spillage:* All boilers must be properly vented. Per the BPI 1200 Standard, the acceptable limit for spillage in a warm vent appliance is two minutes after firing, and for a cold vent appliance, five minutes after firing. All water heaters shall be considered warm vent. The flue must not be clogged, disconnected, or rusted to the point where it leaks. All boilers, with the exception of direct-vent units, must be tested with worst-case draft depressurization test procedures (see Section 5.7

7. *Circulator(s) on hot water boilers:* The motor must be checked for proper operation and oiled (where applicable).

8. *Hot water or steam distribution:* The distribution system should be checked for leaks, proper balancing, and adjustment. Dirty or clogged convectors/radiators must be cleaned.

9. *Other cleaning:* Other necessary cleaning should be done, including air intakes, burners, furnace controls, and heat exchangers.

10. *Replacement units:* Any replacement unit must not be sized by more than 115 percent of the total load; however the next available size may be used.

[11] 40 CFR 271.13

10.3.5 Related Heating System Measurement Techniques

1. *Steady-state efficiency:*

a. *Gas systems:* Follow these procedures for conducting a steady-state efficiency test of a gas heating system.

i. Inspect the unit for hazardous conditions.

ii. Allow the unit to reach a steady state after firing the burner. Measure the temperature before dilution air enters the vent system. When the temperature has stabilized, steady-state conditions have been reached.

iii. With a combustion analyzer, measure the oxygen (O_2) percentage in the flue gas.

iv. Measure the net stack temperature at the same spot(s) the oxygen percentage was measured.

b. *Oil systems:* Follow these procedures for conducting a steady-state efficiency test of an oil heating system. If a visual inspection indicates a cleaning and tuning is necessary, do so before an efficiency test is taken.

i. *Note: Before the efficiency of an oil-fired system is measured, the smoke reading must be taken. If the smoke reading is 2 or less, proceed with the efficiency test; otherwise do not perform an efficiency test on the heating unit. Instead, order or conduct a cleaning and tuning for the burner and heating unit.*

ii. Inspect unit for hazardous conditions.

iii. Allow the unit to reach a steady state after firing the burner. When the temperature has stabilized, steady-state conditions have been reached.

iv. With a combustion analyzer, measure the oxygen (O2) percentage in the flue gas.

v. Measure the net stack temperature at the same spot(s) the oxygen percentage was measured.

vi. Determine the steady-state efficiency from these values.

2. *Measurement of External Static Pressure (ESP):*

a. Refer to Section 5.5.

3. *Measurement of temperature rise:*

a. Refer to Section 5.6.

4. *High-limit furnace control* (supply-side measurement only):

In some cases, this should not be tested on newer furnaces. Refer to the manufacturer's equipment manual. The measured temperature should match the manufactures recommended setting.

a. *Up-flow and horizontal-flow furnaces:* Drill a hole and insert the thermometer in the supply plenum as close as possible to the heat exchanger, but "out of sight" of the heat exchanger (this ensures that the reading will not be affected by radiant thermal energy from the heat exchanger).

b. *Down-flow furnaces* (manufactured home): Place the thermometer through the slots in the top center of the blower compartment cover, with the cover in place.

5. *Heat exchanger integrity:*

a. When performing a steady-state efficiency test on a furnace and the CO or O_2 values change when the furnace distribution blower fan starts, it might indicate a cracked or defective heat exchanger.

10.3.6 Minimum Combustion Air Requirements

Combustion supply air must comply with the requirements of the appropriate National Fire Protection Association (NFPA) documents Standard for the Installation of Oil-Burning Equipment, NFPA 31; National Fuel Gas Code, NFPA 54; or Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burner Appliances, NFPA 211.

10.4 Heating System Replacement

Any heating system replacement must be justified by the approved energy audit with an SIR greater than 1. Installation must conform to state and local codes, including NFPA 211. The following represents the major requirements. For complete details refer to NFPA 211 *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances* and local codes.

All replacement heating systems except wood burning units must meet the following minimum efficiency standards as listed in the AHRI Directory of Certified Product Performance: http://www.ahridirectory.org/ahridirectory/pages/home.aspx.

i. Oil-Fired Boilers, 83% AFUE.

ii. Gas-Fired Boilers, 83% AFUE.

iii. Oil Furnaces, 83% AFUE.

iv. Natural Gas/LP Furnaces, 90% AFUE.

10.4.1 Replacement Specifications

Fuel switching is not an allowable expense under DOE program guidelines.

1. Use the existing distribution system and gas or fuel-oil supply line.
2. Properly remove and dispose of existing unit.
3. Provide an owner's manual with a heating system replacement.

4. Properly size replacement heating systems units according to Manual J[12] or an equivalent sizing formula.
5. Install a condensate pump where needed to reach an appropriate drain.
6. Seal openings in chimneys where natural draft appliances are eliminated. A written notice posted on the chimney, where sealed, that the chimney is no longer functional is recommended.
7. The heating system installer must guarantee materials and labor for the replaced heating system for a period of one year.

10.5 Space Heater Replacement, Excluding Solid-Fuel Appliances

1. MaineHousing requires removal of all unvented gas- and liquid-fueled space heaters and replacement with vented, code-compliant heating systems as a prerequisite to weatherization.
    a. In homes where unvented space heaters are the primary heating source and there is no repairable existing vented heat source, the agency must install a vented heating system whenever cost effective. If this is not possible, no weatherization work may be done. In most cases, this will require the installation of a direct-vent wall heater(s). This policy is based on the fact that weatherization of the dwelling will result in the probability of increased moisture and indoor air quality issues resulting from an unvented space heater.
    b. Unvented gas- or liquid-fueled space heaters may remain as secondary heat sources in single-family houses provided they comply with local codes and ANSI Z21.11.2. Funds may not be used to replace unvented secondary space heaters. Any unvented gas- or liquid-fueled space heaters that remain in a single-family house after weatherization:
        i. Shall not have an input rating in excess of 40,000 Btu/hour;
        ii. Shall not be located in, or obtain combustion air from sleeping rooms, bathrooms, toilet rooms, or storage closets, unless:
            (1) Where approved by the authority having jurisdiction, one listed wall-mounted space heater in a bathroom with an input rating that does not exceed 6,000 Btu/hour, is equipped with an oxygen-depletion sensing safety shut-off system, and the bathroom meets required volume criteria to provide adequate combustion air;
            (2) Where approved by the authority having jurisdiction, one listed wall-mounted space heater in a bedroom with an input rating that does not exceed 10,000 Btu/hour, is equipped with an oxygen-depletion sensing safety shut-off system, and the bedroom meets required volume criteria to provide adequate combustion air.

[12] *Residential Load Calculation* by the Air Conditioning Contractors of America (ACCA).

11 Heating Distribution Systems

11.1 Ducted Distribution Requirements

11.1.1 Duct Leakage

Duct leaks can lead to many problems in a dwelling, the most common one being wasted energy. Other problems can include thermal discomfort, substandard indoor air quality, and hazardous combustion venting.

Duct leaks can be 1) within the confines of the conditioned (thermal/pressure) envelope of the building or 2) outside of the thermal/pressure envelope.

Air leakage to or from the outdoors wastes more energy than leakage within the confines of the thermal envelope. Manufactured home ducts and site-built homes with ductwork in crawl spaces or attics are susceptible to leakage to and from the outdoors.

On the other hand, although duct leakage within the conditioned envelope usually does not have a significant energy impact, it might impose a hazard to occupant health by causing poor indoor air quality or backdrafting of combustion appliances. These potential problems are addressed on-site by an Indoor Air Quality (IAQ) appraisal, and by performing the worst-case depressurization test (refer to Section 5.7).

Pressure pan testing must be performed in manufactured homes and double-wides to determine if the ducts are leaking to a significant degree to or from the outdoors.

11.1.2 Duct Leakage Standards for Site-Build Homes

1. MaineHousing requires worst-case depressurization testing before weatherizing to determine whether the furnace air handler affects the pressure in the combustion appliance zone (CAZ). Refer to Section 5.7
    a. To conduct this test, measure the pressure in the CAZ with reference to the outdoors with the furnace air handler off and then on.
    b. Make certain the basement door to the upstairs is closed and the basement or crawl space is closed to the outdoors as much as possible.
    c. If the air handler significantly affects the pressure in the CAZ, call for the appropriate duct sealing on the job work order.
2. For ducts located in unconditioned spaces:
    a. If possible, convert the unconditioned space where the ducts are located to a conditioned space, making sure the air and thermal barriers are effectively installed.
        i. Demonstrate the effectiveness of this weatherization work by performing a house-to-zone pressure and flow zone pressure diagnostics test (if

possible) before and after converting the unconditioned space to a conditioned space.

ii. Always repair disconnected ducts.

iii. Sealing the envelope of the space rather than the duct joints is preferred; however, significant duct leakage should be repaired.

b. If the unconditioned space is impossible or impractical to convert to a conditioned space (examples of these types of unconditioned spaces include crawl spaces, unconditioned basements, attics, attached or tuck-under garages, and exterior walls):

i. Make all necessary ductwork repairs, seal all ductwork joints with mastic, and thermally insulate ducts in unconditioned spaces to at least R-8.

3. For ducts located in conditioned spaces, such as a basement or crawl space:

a. Visually inspect the conditioned space to ensure that the shell is properly air sealed and insulated.

b. If it is determined that weatherization work should be done to the thermal/pressure boundary of the conditioned space that houses the ducts, perform a house-to-zone pressure and flow test (zone pressure diagnostics) before and after the work to quantify the effectiveness of the work.

i. Always repair disconnected ducts in the space.

ii. Sealing the envelope of the space rather than the duct joints is preferred.

c. There are a number of techniques that can be used to help find hidden leaks in ductwork. These include:

i. Careful visual inspection.

ii. Operating the air handler while searching for leaks. Existing leaks often become leakier if the conditioned basement or crawl space is opened to the outdoors.

iii. Pressure pan testing at registers and grilles while the blower door is operating and the basement or crawl space is opened to the outdoors.

11.1.3 Duct Leakage Standards for Manufactured Housing

MaineHousing expects the duct leakage standards below to be followed. If they cannot be complied with, documentation regarding noncompliance must be put in the client file with reasons demonstrating that compliance was not cost effective.

1. If there is a belly return system in the manufactured home or double-wide, convert it to a living-space-return system (refer to Section 9.6.2).

11.1.5 Duct Sealing

1. Gaps larger than ¼ inch between the air handler and adjoining ductwork or equipment will be bridged with sheet metal.
2. Other accessible duct joints, cracks, seams, holes, and penetrations shall be sealed as specified below:
    a. Surfaces shall be properly cleaned before sealing.
    b. Seams, cracks, holes, and penetrations less than ¼ inch will be sealed using fiberglass mesh and mastic.
    c. Seams, cracks, holes, and penetrations between ¼ and ¾ inch will be sealed in two stages:
        i. They will be backed using temporary tape – duct tape – as a support prior to sealing;
        ii. They will be sealed using fiberglass mesh and mastic. Fiberglass mesh and mastic shall overlap the temporary tape by at least 1 inch on all sides.
    d. Seams, cracks, holes, and penetrations larger than ¾ inch shall be repaired using rigid duct material.
        i. Fiberglass mesh and mastic shall overlap the repair joint by at least 1 inch on all sides.
3. Installation of mastic will be applied in a manner that meets manufacturer's specifications, as well as UL 181M, NFPA 90A and NFPA 90B.
4. In manufactured homes, if the boot is loose to the floor, it shall be reattached to the subfloor with permanent fasteners such as roofing nails, staples or wood screws. Ensure that any fasteners do not prevent the register or grille from fitting properly into the boot.
    a. If gaps exist between the boot and the floor and the space below the floor is unconditioned, fill the gaps with fiber tape and mastic or other appropriate materials. It may be necessary to use a cleaning solvent such as mineral spirits or denatured alcohol to eliminate any greasy buildup to ensure the duct sealing material will adhere properly.

11.1.6 Ductwork Sealing Materials

1. Cloth duct tape shall never be used for duct sealing, except as temporary tape.
2. Existing duct tape must be removed before installing duct mastic or other approved sealing materials, except when used as temporary backing tape (refer to Section 2.1.3.2.c).
3. Mastic shall meet the following requirements:
    a. Non-toxic and water-resistant.

b. UL listed and labeled per UL 181A or 181B standards.

c. Shall be compatible with the duct material to which it is applied.

4. Mesh fabric used to reinforce duct mastic shall meet the following requirements:

   a. Comply with the mastic manufacturer's specifications.

   b. Made of fiberglass.

   c. Have at least a 9 x 9 weave per inch.

   d. Be at least 0.006 inches in thickness.

5. For flexible ductwork:

   a. UL 181 BM listed tapes and mastic products will be used to seal the interior liner.

   b. All accessible joints, seams, and connections will be sealed with UL 181 approved mastics.

   c. Vapor barrier of all duct insulation will be taped to the flex duct using the taping system required by the manufacturer of the duct insulation.

6. Draw bands used to support or seal ductwork shall meet the following requirements:

   a. Comply with the manufacturer's installation instructions.

   b. Weather- and UV-resistant duct ties or stainless steel worm drive clamps

   c. Loop tensile strength must be at least 150 pounds.

   d. Service temperature rating must be at least 165^{o}F.

7. Duct supports shall conform to the duct manufacturer's installation instructions and must be corrosion resistant.

11.1.7 Ductwork Insulation

1. Active ductwork outside the thermal/pressure envelope must be repaired if damaged, sealed, and insulated.

   a. Prior to installing insulation, ductwork must be sealed according to these standards, Section 2.1.3.

   b. Exception: Inaccessible parts of the distribution system do not require thermal insulation. Inaccessible means nearly impossible to insulate because of location or obstructions.

2. Supply and return ducts and plenums in conditioned spaces do not require thermal insulation.

   a. *Exception:* There might be cases where duct insulation is appropriate in a conditioned area, such as a basement. For example, if there is not adequate heat getting to a room, the branch duct may be insulated for reasons of thermal

comfort as long as the following items have been checked and/or implemented first:

i. There are no branch duct obstructions to airflow.

ii. The branch duct balancing damper is fully open.

iii. The branch duct air leakage has been checked and sealed, if necessary.

3. Combustion or exhaust vents should not be insulated.
4. For ductwork that is not within the thermal boundaries of the dwelling, install a minimum of R-8 (preferably R-11, when possible) on ducts and plenums.
   a. If ductwork is already insulated to a level of R-4 or greater, no additional insulation is required, however, make appropriate repairs to the existing insulation.
5. Insulation must have a flame spread rating no greater than 25.
6. Only vinyl-backed or reinforced foil duct wrap is to be used on ducts.
7. The duct insulation should be installed with the vapor barrier on the outside, which will serve to cover the insulation.
8. Do not wrap duct insulation so tightly that it is excessively compressed. It should not be compressed more than 50 percent of normal thickness.
9. Maintain a minimum of 6 inches between duct/pipe insulation and all heat sources;
10. Install protective covering around the insulation where required by local regulations.

11.1.8 New Ductwork Installations

1. Ducts, supply registers, and return grilles shall be sized and selected according to the latest editions of *Residential Duct Systems*, Manual D, by ACCA; *Residential Comfort System Installation Standards Manual* by the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA); or a comparable industry-accepted method.
2. Attempt to install all new ductwork within conditioned spaces.
3. Do not install ductwork within exterior walls.
4. All distribution-air enclosures must be hard-ducted, that is, building frame cavities, closets, crawl spaces, and chases must not be used as distribution-air enclosures. However, ductwork may be housed by, or pass through these spaces.
5. Ductwork must be installed at least 4 inches from any bare earth.
6. Panned floor joists may not be used for air distribution.
7. A crawl space may not serve as a distribution plenum.
8. Do not use a dropped ceiling cavity as a plenum.

9. Ductwork, filter, and other equipment shall be installed so that total external static pressure does not exceed the furnace manufacturer's specifications.

11.2 Piped Distribution Requirements

Treatment of distribution pipes for hot water or steam heat is dependent on a number of factors, including its location, accessibility, and its condition.

11.2.1 Steam and Hot Water Heating Distribution Pipes

1. Make certain there are no leaks in hot water or steam distribution pipes.
2. Supply and return lines in unconditioned spaces must be insulated if they are accessible.
3. Pipes may be insulated within the habitable space if it is determined that the space does not require heating or is overheated.
4. Pipe insulation must be sized to the pipe being insulated.
5. Secure the pipe insulation with mechanical fasteners or appropriate tape.
6. Pipe insulation must have mitered cuts at corner joints. Tape joints appropriately.
7. Pumps, valves, pressure relief devices, or vents should not be insulated. Do not insulate over heat tape.
8. Closed cell foam, high temperature rated insulation or elastomeric pipe insulation should be used that has a flame spread rating no greater than 25.
9. Maintain a minimum of 6 inches between pipe insulation and all heat sources.

12. Baseload Measures

Baseload measures include any appliance or device that uses energy, but is not related directly to space heating or cooling. Examples include water heating, refrigeration, lighting, and clothes washers and dryers.

12.1 Water Heaters

Generally water heating is the largest part of baseload energy use. The energy used for water heating can be reduced in a number of ways, including insulating the storage tank and distribution pipes, lowering the hot water temperature, and using less hot water.

12.1.1 Combustion Type Water Heater Inspection

All water heaters must meet the following specifications:

1. All gas leaks should be documented in the client file. All identified gas leaks should be reported to the client and referred to a licensed technician for repair.
2. All water heaters must be properly vented.

3. All fossil-fuel water heaters, with the exception of direct-vent units, must be tested with worst-case depressurization test procedures (see Section 5.7 for details). This includes testing for spillage, if applicable, during worst-case depressurization. As all water heaters are considered warm vent appliances, Per the BPI 1200 Standard, the acceptable limit for spillage is two minutes after firing.
4. All gas-fired direct-vent (sealed combustion) and atmospheric combustion water heaters must be tested for carbon monoxide emissions. Measured carbon monoxide levels must be equal to or less than 200 ppm as-measured or 400 ppm air-free.
5. All water heaters must have a water temperature test. If the water temperature is above 120^{o}F at a faucet near the water heater, the client should be informed about the advantages and disadvantages of lowering the water temperature.
6. Visually inspect the combustion chamber for rust, dirt, and proper burner alignment. Visually inspect the venting, plumbing, and gas piping. Check the tank for water leaks and note any code violations.

12.1.2 Domestic Hot Water Pipes

1. Make certain there are no leaks in domestic hot water pipes.
2. Insulate the first 6 feet of hot water pipe and the first 6 feet of cold water pipe with ¾-inch pipe insulation.
3. Closed cell foam, high temperature rated insulation or elastomeric pipe insulation should be used that has a flame spread rating no greater than 25.
4. Maintain a minimum of 6 inches between pipe insulation and all heat sources.
5. Domestic hot water pipes running through unconditioned spaces must be insulated if accessible.

12.1.3 Water Heater Replacement and Installation

Replacement or repair is allowed where client health may be a concern. In such cases, weatherization may not proceed until the health and safety concern is addressed. Accepted industry procedures and practices will be followed for water heater removal and replacement.

1. An emergency drain pan shall be installed a minimum of 4 inches above the floor. A ¾-inch drain line, or larger, shall be connected to tapping on the drain pan and run to a drain or pumped to daylight.
2. A stainless steel bladder expansion tank shall be installed on the cold water side.
3. Temperature/pressure relief value, dielectric unions, and backflow prevention shall be installed according to the manufacturer's specifications.
4. The following shall be checked once the new system has been filled and purged:
    a. Safety controls.

b. Combustion safety and efficiency.

c. Operational controls.

d. Fuel and water leaks.

e. Local code requirements

6. The occupants shall be educated on the safe and efficient operation and maintenance of the new water heater, including:

   a. Adjustment of water heater temperature.

   b. Periodic drain and flush.

   c. Expansion tank and backflow preventer (no occupant maintenance required).

   d. Periodic inspection.

12.1.4 Water Heater Blankets

The installation of water heater blankets on electric water heaters in conditioned spaces is recommended unless this will void the water heater warranty. Gas water heaters should not be insulated.

Water heaters located in unconditioned areas should be moved to a conditioned area, if possible. If the water heater cannot be moved, the heater and distribution pipes, both hot and cold, must be insulated.

12.1.4.1 Water Heater Blanket Materials and Installation

1. The water heater blanket must be fiberglass batt insulation with a protective covering.
2. An R-11 water heater blanket is preferred unless prohibited by the manufacturer.
3. A water heater blanket must be secured to the water heater with at least two (2) straps with buckles. The installed straps must not excessively compress the water heater blanket.
4. The water heater tank must be inspected to determine the type of water heater (gas, electric, etc.), and whenever possible, the amount of existing insulation.
5. If there are signs that the water heater is leaking, the leak(s) must be repaired before insulation is added.
6. Functioning electric water heaters installed outside the conditioned space, including manufactured home water heaters in exterior closets, must be insulated if the total existing tank insulation is less than R-11.
7. Do not install a water heater blanket if a temperature and pressure relief valve does not exist or when the existing temperature and pressure relief does not operate properly.

8. A water heater blanket must not cover the following:
    a. The temperature and pressure relief valve on an electric unit.
    b. The drain valve on an electric unit.
    c. Where the electrical line attaches to an electric unit. Insulation must be - kept at least two inches away from where this electrical line attaches to the water heater.

12.1.5 Domestic Hot Water Temperature

Whenever feasible, the domestic hot water temperature must be measured. If the water temperature is above 120°F at a faucet near the water heater, the client should be informed about the advantages and disadvantages of lowering the water temperature.

12.1.6 Energy-Saving Showerheads

1. An energy-saving (low-flow) showerhead- may be installed with client permission, if the existing showerhead flow is measured at greater than 3 gallons per minute (GPM) and the installation does not require the use of a plumber.
2. The energy-saving showerhead must have a flow rating of 1.75 GPM or less. If multiple shower heads are provided for one shower unit, the total flow rate shall not exceed 3.5 GPM.
3. Replaced shower head(s) shall be removed from the home.
4. The occupant's acceptance of a shower head should be documented in the client file.

12.2 Refrigerator Metering and Replacement

12.2.1 Introduction

If an eligible household has an inefficient refrigerator that has been determined to be replaceable and the household has a secondary refrigerator or freezer, then the agency may trade up to a larger Energy star rated model refrigerator if the applicant agrees to have both the existing units removed.

1. The client is required to give up possession of the old refrigerator. It must be removed from the premises, de-manufactured, and properly disposed of by the supplier of the new appliance. The refrigerator supplier must provide documentation of delivery and proper disposal to the agency.
2. The estimate of the kWh/yr. for the existing refrigerator shall be determined by one of the two methods below:
    a. An estimate of KWh/yr. usage and annual cost for electric hot water heaters, based on estimated daily use can be calculated at http://energyusecalculator.com/electricity_waterheater.htm http://energyusecalculator.com/electricity_refrigerator.htm

b. Identify the make and model number of the refrigerator. Find the brand, model, and annual electrical consumption in a reliable listing of refrigerators at http://www.kouba-cavallo.com/refmods.htm, if appropriate, multiply the annual kWh/yr. consumption estimate listed by the degradation multiplier listed in Table 3-1.

Table 3-1

Refrigerator Degradation Multipliers	
Refrigerator Age	*Multipliers*
Less than 5 years	1.0
5 to 10 years	1.1
10 to 15 years	1.2
More than 15 years	1.3

3. The basis for replacing a refrigerator is its Savings-to-Investment Ratio (SIR) value. If the SIR for replacing a refrigerator is 1.00 or greater, the refrigerator should be replaced.

12.2.2 Procedures for - Replacement of Refrigerators

1. Auditors will:

   a. –Determine the SIR generated by the proposed new Energy Star refrigerator by comparing its cost to the estimated annual kwh savings over the existing unit, times the estimated lifetime of the replacement refrigerator in years times the average kwh cost for the state of Maine, e.g. $0.11/kwh. Example: New unit cost $975; annual kwh savings = 725kwh times the estimated lifetime of new refrigerator, 13 years, times $0.11. (725 x 13 x $0.11)/$975 = $1036.75/$975 = 1.06.

   b. In order to replace the refrigerator, the Savings-to-Investment Ratio (SIR) must be at least 1.0 and high enough to be included on the “to do” list of energy saving measures for the house.

2. Take all necessary measurements to make sure the existing and new units can be moved out of and into the kitchen:

   a. Take and record the outside dimensions of refrigerator.

   b. Take measurements of all doors through which the existing and new refrigerators will have to be moved. Make sure that all doors, hallways, and stairways will accommodate the existing and the new unit. Leave ½ inch for clearance. The door to the refrigerator can be taken off, if needed, to gain 1.5 inches.

3. All replacement refrigerators shall be white in color, unless the client is willing to pay the cost difference for the color of their choice.

4. Go through the applicant education process, whether or not refrigerator(s) and/or freezer(s) are being replaced.

5. The work orders must show the manufacturer, model number, and the vendor job number.

6. Control settings in new refrigerators should be set to “2” by the vendor. The applicant should be advised during applicant education that the settings of new refrigerators should be kept at 2.
7. The vendor shall make sure that the new refrigerator is level and plumb.
8. The vendor obtains client signatures on a vendor-supplied form to verify delivery and removal of appliance(s).
9. The vendor must remove and properly dispose of existing appliance(s) and provide documentation to the agency regarding delivery and proper disposal. The agency will provide copies to MaineHousing of the proper disposal.

12.3 Incandescent Bulb Replacement with CFLs

12.3.1 Introduction

Advanced technology enables CFLs to use up to 75 percent less energy than a standard incandescent bulb and last up to 10 times longer. This means that over the life of one CFL, a client can avoid replacing up to 13 incandescent bulbs.

ENERGY STAR® CFLs emit the same amount of light as standard bulbs, but have lower wattage ratings because they use less energy. The Wattage of an efficient CFL is about ¼ to ⅓ that of a typical incandescent, for a given level of light output.

12.3.2 Replacement Procedure

1. All replacement CFLs must be ENERGY STAR® rated.
2. Collect the following information:
    a. The cost of electricity in dollars and cents per kWh;
    b. The number of hours of use per day for each existing lamp;
    c. The existing wattage of the incandescent lamp being replaced;
    d. The proposed wattage of each new lamp; and
    e. The cost of each new lamp.
3. With the above information from the inventory of bulbs in the dwelling, fill out the MaineHousing approved energy audit form.
4. If the savings-to-investment ratio for replacement of an incandescent bulb with a CFL is 1.0 or more, the replacement should be done.

12.3.3 Replacement Guidelines for CFLs

1. When replacing incandescent bulbs with CFLs, match the lumen output of the CFL to that of the replaced incandescent, rather than the Wattage.

2. A correlated color temperature of 2700 K or 3000 K is recommended. These are often referred to as “warm white” or “soft white”. Higher correlated color temperatures are bluer in color.
3. If CFLs are controlled by dimmer switches, the appropriate CFL shall be used.

12.4 Gas Range Inspection[13]

Gas ranges shall be inspected and appropriate client education shall be delivered to an adult client in the household. A carbon monoxide (CO) alarm must be already in place or installed within or near the kitchen where the gas range is installed.

12.4.1 Inspection and Client Education

12.4.1.1 Gas Range Inspection

1. Range-top inspection:
    a. Inspect the range-top burner area for cleanliness. If the burners or burner area are dirty enough to adversely impact the combustion process, inform the client that the range should be cleaned to reduce the possibility of unacceptable carbon monoxide emissions.
    b. Inspect the burners for proper alignment and seating.
    c. All cooking vessel support grates should:
        i. Be in place,
        ii. Fit properly in the burner well, and
        iii. Be in one piece, with no broken parts.
    d. If any of the grates are missing or in unsatisfactory condition, the client should not use the affected range burner(s) until the substandard or missing grate is replaced.
    e. If the range-top burners are ignited with a standing pilot light, verify that the pilot is lit, is about 5/16 in length, and is soft blue in color (not yellow).
    f. Ignite each burner for at least 30 seconds to inspect its flame for color and noise.
        i. The flames should have sharp blue edges with orange specks rising through the flames (dust particles). Make sure there is no significant yellow at the upper tips of the flames.

[13] Metered testing of carbon monoxide emissions from range top burners or bake ovens is not required by this procedure.

ii. You should be able to hear the gas flow in a quiet kitchen. The sound should not be loud or irregular.

2. Oven area inspection:

   a. Inspect the oven for cleanliness. If the burners or oven area are dirty enough to adversely impact the combustion process, inform the client that the range should be cleaned to reduce the possibility of unacceptable carbon monoxide emissions. Do not test for CO emissions until the problem is corrected.

   b. Check the oven's bottom vents for blockage. These vent holes must not be blocked by anything in the oven, such as aluminum foil. The vent openings must never be obstructed because they are an important part of the oven combustion venting system.

   c. Check the bottom of the range and drawer and/or the broiler compartment under the oven for air blockage. Dust, lint, pet hair, rugs, or any other obstruction blocking free airflow to the oven's bake burner must be removed by the owner.

   d. Check the oven bake-burner spreader plate (burner baffle). Most bake burners (the one at the bottom of the oven compartment) have a flame spreader plate just under the oven compartment bottom and above the bake burner flame (typically, this plate is attached to the oven bottom). Warped or detached spreader plates can impinge and quench (cool) the gas flame, increasing the production of carbon monoxide. Many spreader plates are intentionally bent into curved or angular shapes, or dimpled, to add strength. Carefully inspect with a flashlight and mirror to determine if the spreader plate has distorted from its original shape or has detached from the oven bottom. Ignite the bake burner to inspect the flame. The flame should not extend beyond the edge of the spreader plate. Also, inspect for carbon buildup on the spreader plate and the oven bottom. Any carbon buildup can be an indication of incomplete combustion caused by flame quenching or a fuel-rich gas mixture.

   e. If the range also has a broil burner at the top of the oven compartment, check its flame for proper size and color.

   f. Inspect the oven compartment and under the oven compartment for any other defects that could lead to unacceptable CO emissions.

   g. If the oven burner(s) is ignited with a standing pilot light, verify that the pilot is lit, is about 5/16 in length, and is soft blue in color (not yellow). When properly adjusted, a standing pilot uses about 75 Btuh.

3. Inspect the gas range installation for code compliance. Refer to the latest edition of the National Fuel Gas Code (NFPA 54): Household Cooking Appliances.

4. Verify that the range is set up for the appropriate supply gas.

a. If a range is set up for natural gas but has propane piped to it, it will be over-firing, probably creating hazardous levels of CO. A gas range in this condition must not be used until the problem is corrected. Symptoms of this problem include noisy flames, yellow flames, and large flames rising above the cooking vessel support grates on the range-top burners, carbon (smoke) emissions, or unacceptable carbon monoxide emissions.

b. If a range is set up for propane but has natural gas piped to it, it will be under-firing. In this case, the client might complain of the long period required to boil water or the amount of time required for baking. This condition is usually not hazardous, but it should be corrected.

c. Methods for verifying supply gas type and range setup:

i. Client interview:

(1) Ask client about the history of the gas range. Is it new? Is it a recently acquired pre-owned range? If so, do they know where it was obtained? The client's answers might indicate the gas for which the range was set up at its last location.

(2) Ask the client if they have noticed any flame irregularities. Have the flames been too big, yellow, or noisy? Are the flames very small? Is the cooking or baking taking too long?

ii. Flame inspection:

(1) Range-top burner flames should appear normal in size, color, and sound on the high setting. If the flames appear over-fired or under-fired, it is likely that there is a set up/gas supply mismatch.

iii. Determine the gas type piped to the range:

(1) Ask client what type of gas the range uses. Verify this by checking for a natural gas meter or propane tank and the corresponding piping to the appliance.

d. If it is determined that the range setup gas does not match the supply gas, the client must not use the range until the mismatch is corrected.

5. Check for a flexible connector. If the flexible gas connector can be inspected without moving the range, or if the range is moved out for replacement, make sure the flexible connector is:

a. Not brass,

b. Is not a two-piece connector, and

c. Has no pre-1973 rings (in some cases, the date can be found on the flare nuts rather than the date rings).

6. Do not move the range for the sole purpose of inspecting the flexible connector; this movement might crack or otherwise damage it.
7. Check for gas leaks in the range-top burner area, oven area, and in any accessible gas lines with an appropriate combustible gas detector. Check for propane leaks below connections (propane settles) and for natural gas leaks above connections (natural gas rises). If any gas leaks are found, specify the necessary repair work. Shut off the gas to the appliance and do not proceed with testing until the leak is repaired.
8. Measure CO in the undiluted flue gases in the oven vent. CO must not exceed 200ppm as-measured or 800ppm air-free. See section 4.18.1,5,b.
9. If the gas range fails any of these inspections above, or if the field analyst believes, for any reason beyond the scope of this protocol, that the range burners or the oven bake burner are emitting unacceptable levels of carbon monoxide, inform the client of the dangers. The range must be repaired or replaced. Health & Safety program guidance allows weatherization funds to be used for repair but not replacement.

12.4.1.2 Client Education

Educating the client is - very important. Always take the time to explain the following gas range topics to the client:

1. The holes in the oven bottom must never be blocked with aluminum foil or anything else. Storing too much in the broiler or drawer area under the bake oven can also block the vent holes. This blockage can result in unacceptable carbon monoxide emissions.
2. Do not use the range-top burners or the oven burner(s) as a space heater. Manufacturers recommend against such use; gas ranges are not designed for this.
3. Any dwelling that has a gas range or another combustion appliance must have a working carbon monoxide alarm. An existing CO alarm should be maintained properly. If a new CO alarm will be installed as part of the weatherization services, explain the proper use and maintenance.
4. Have the range checked and tuned once every two years by a technician with an instrument capable of measuring carbon monoxide. This checkup and tuning should include:
    a. Testing of the range's gas pressure.
    b. Making all necessary adjustments for the acceptable operation of all burners. The level of carbon monoxide emissions from a burner can only be determined with an instrument that measures CO and O_2; it cannot be determined by visual inspection of the flames.

5. The oven should be kept reasonably clean at all times. There is evidence that dirty ovens emit more CO than clean ovens.

6. The flames from gas burners – both natural gas and propane – should burn steadily with a clear, blue flame. The flame normally makes a slight hissing sound, but it should not sound like a blowtorch. If the flames burn yellow and/or burn loudly or irregularly, the gas range should be serviced as soon as possible. Avoid using a bad burner until it is properly adjusted or repaired.

13 Final Inspection Procedures

The Department of Energy and MaineHousing require that final inspections be performed to assess adequacy and quality of work. The DOE rule reads as follows:

"No dwelling unit may be reported to DOE (or MaineHousing) as completed until all weatherization materials have been installed and the agency (the CAA) or its authorized representative, has performed a final inspection(s) including any mechanical work performed and certified that the work has been completed in a workmanlike manner and in accordance with the priority determined by the audit procedures required by 440.21."[14]

The final inspection must be performed by a certified Quality Control Inspector who was not involved in conducting the energy audit,

Exceptions may be made due to agency staffing levels. If a Subgrantee cannot meet this requirement, the Subgrantee must explain the circumstances and outline their audit and inspection procedures in the Work Plan submitted to MaineHousing for approval. Subgrantees in this category are subject to increased Grantee Monitoring.

13.1 General Final Inspection Items

The following final inspection procedures shall be employed when and where applicable:

1. All repair and installation work shall conform to the Maine State Historic Preservation Office guidelines[15] and local building codes when applicable, including, but not limited to the *Maine Plumbing Code*; the NFPA 70 *National Electric Code*; NFPA 101 *Life Safety Code*; NFPA 31 Standard for the *Installation of Oil-Burning Equipment*; NFPA 54 *National Fuel Gas Code*; NFPA 211 *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances;* the *International Residential Code* 2009; the *International Existing Building Code* 2009; and ASHRAE 62.2-2010 *Ventilation and Indoor Air Quality in Low-Rise Residential Buildings*. All repair and installation work shall conform to local and state building codes when applicable. Please refer to Section 1.5.
2. The inspecting Quality Control Inspector (QCI) is responsible for ensuring all items specified in the work order have been completed and installed in accordance with the specifications in the Maine Weatherization Field Guide (SWS), Maine Weatherization Standards and Maine Weatherization Task Specifications. The QCI shall assess the job to ensure that the contractor has not damaged any existing finishes and items in the home.
3. The QCI shall also ensure that the contractor or crew have left the dwelling in a clean and orderly manner.
4. The work order shall be followed at all times during the final inspection.

[14] U.S. Department of Energy - *Weatherization Assistance Program for Low-Income Persons* - Title 10, Part 440, Final Rule - Revised as of December 8, 2000, section 440.16.(5).(c).
[15] Please see the Maine Weatherization Program Section 106 Checklist.

a. Any items that have not been completed in accordance with the Maine Weatherization Field Guide (SWS), Maine Weatherization Standards and Task Code Specifications must be documented on the work order and appropriate action taken as a rework or de-bill.

b. If the inspecting QCI identifies missed opportunities for potentially significant energy savings or health and safety issues, they must be documented on the work order and evaluated and addressed when practicable.

5. The inspecting QCI is responsible for obtaining all the proper homeowner signatures on the final sign-off for the project.

6. All paperwork is required to be placed in the client file.

13.2 Inspection of Attic Insulation

1. Visually inspect interior ceilings and ensure that damaged ceiling components have been repaired or replaced as needed. Verify that the ceiling can safely hold the weight of the insulation.

2. Verify that all voids and areas of incomplete coverage in the existing insulation have been addressed.

3. Verify all installed attic bypass and safety items have been addressed properly, including but not limited to:

   a. Chimney bypasses.

   b. Plumbing stack bypasses.

   c. Attic hatch or pull-down stair sealing and insulating.

   d. Recessed light damming.

   e. Junction boxes addressed and flagged.

   f. Bathroom, kitchen, and whole-building exhaust fan venting.

   g. Knob-and-tube wiring.

4. Verify that the proper type and amount of attic insulation has been installed.

   a. Check for depth gauges and insulation verification label. Open blown cellulose insulation must be installed to allow for 10 percent settling. For example, if 14 inches of cellulose are called for on the work order, 16 inches must be installed so that the settled thickness is 14 inches.

   b. The thickness of open blown cellulose insulation should be uniform throughout. The final top surface of the insulation must be reasonably level and uniform.

5. Verify that attic ventilation is added as specified in the work order and installed insulation does not obstruct attic ventilation.

13.3 Inspection of Attic Access and Knee Wall Doors

1. When it is not structurally prohibited to install, verify the attic hatch is at least 4 square feet and at least 20 inches in width or length and weather stripped. Additionally, the hatch shall be latched and insulated with at least 4 inches of extruded polystyrene (R-20) that is properly secured to the exterior surface of the attic hatch.
2. Verify that the pull-down stair opening is properly insulated, latched and weather stripped.
3. Make sure knee wall access doors are properly insulated, weather stripped, and latched.

13.4 Inspection of Wall Insulation

1. Use infrared scanning whenever conditions allow.
2. Verify sidewall insulation has been installed in all accessible wall cavities and verify voids are no greater than 5 percent. Refer to Section 7.3.10.
3. All structural repairs identified on the work order should have been completed before the installation of wall insulation. This may include:
    a. Exterior moisture damaged areas, such as missing or rotted siding or trim boards.
    b. Deteriorated window or door components.
    c. Missing or damaged siding or trim boards.
4. Any replaced wood siding or trim must match the existing grade and be primed.
5. Verify that blown insulation has not deformed or damaged the interior wall surfaces.
6. If the insulation was blown into the wall cavities from the inside, make sure that:
    a. Interior fill holes have been filled properly and patched and that the final finish is as close to the original as possible.
    b. No insulation or debris is left in the house.
7. Verify insulation has not penetrated into wall heaters, vent fans, ducts, or other mechanical equipment.
8. Make sure that structural details such as interior soffits, pocket doors, and other bypasses have been properly addressed during the insulation installation.
9. Make sure the siding has been reinstalled properly and not damaged.
10. If the finished siding has been face-drilled and plugged, document the reasons in the client file and include a permission form signed by the client.
11. Verify that cellulose insulation has been installed at the proper density.
    a. Cellulose must be installed at a density of at least 3.25 pounds per cubic foot whenever conditions permit.
    b. The density shall be determined by one of the following methods:

i. Core sampling after the insulation is installed using the thermal infrared imaging to help assist in determining sample locations; or

ii. Calculating density *during* installation by determining the cubic feet of wall to be insulated, taking note of the number of pounds of insulation installed in the calculated cubic feet of wall, and then figuring the pounds per cubic feet of installed cellulose; or

iii. Other methods approved by MaineHousing.

13.5 Inspection of Basement and Crawl Space Insulation

1. Verify that the treatment of a basement or crawl space corresponds with the appropriate definition of the thermal boundaries of the dwelling. See Section 7.4.5 Make sure that all foundation air sealing has been completed.
2. Verify that allowable repairs have been made to correct any moisture or sewage problems.
    a. If moisture or sewerage problems are identified at the time of the final inspection, consult a MaineHousing Technical Services Specialist to determine course of action.
3. Verify that all insulation installation required by the work order has been properly installed.
4. Verify that an appropriate ground cover has been installed in crawl spaces, when warranted and possible.
5. Verify that water lines have been protected from freezing, if necessary.
6. Verify that damaged or missing exterior doors have been repaired or replaced and that they are weather stripped and insulated.

13.6 Inspection of Dryer Vent

Verify that the dryer is properly vented to the outdoors and that the damper in the dryer vent is working properly. Verify that the dryer vent is installed according to Section 4.15.4

13.7 Inspection of Kitchen, Bathroom, and Whole-Building Exhaust Fans

1. Verify that all exhaust fans are properly vented to a weather-protected termination fixture located on the outside of the dwelling, either through a sidewall or roof by means of the appropriate duct specified in Section 4.16.6.
2. Verify that all exhaust fans comply with Section 4.16, ASHRAE Standard 62.2-2016.
3. Make sure the client understands the importance and proper use of all newly installed exhaust fans.
4. Verify that the exhaust fans are working properly and are exhausting at the specified CFM rate.
    a. Measure the actual exhaust fan CFM rate with an appropriate fan-flow meter.
5. Verify that ventilation air circulates freely between rooms. With all interior doors closed and ventilation systems on, test room pressures with reference to outdoors using a manometer. No

room will exceed +/- 3 pascals pressure difference; Install measures such as door undercuts or vents to reduce pressure difference to +/-3 pascals. (Maine Weatherization Field Guide (SWS) 6.6201.2a Balancing Pressure).

14 Diagnostic Testing Procedures

14.1 Blower Door Testing

The use of a blower door as a weatherization tool is very important. It is used to determine the pre- and post-weatherization dwelling leakage rates, giving the crew or contractor an accurate idea of the effectiveness of their air sealing efforts. In addition, the blower door is used for zone pressure testing and duct leakage testing.

Because the blower door is such an important weatherization tool, it is very important that it be set up and used properly at each weatherization job. The **depressurization** blower door test is preferred for Maine Weatherization because it takes less time to perform than a pressurization test, and it is the standard test used in the low-income weatherization program across the United States.

The blower door testing procedures below assume the use of the Energy Conservatory's Minneapolis Blower Door, Model 3, with the companion DG-700 digital manometer (pressure gauge).

14.1.1 Preparation for Blower Door Test

1. Agencies and contractors should maintain accurate calibration of their blower doors and related equipment. This includes:
    a. Blower door fan.
        i. There should be no physical damage to the fan.
        ii. The flow sensor is one of the most critical parts of the blower door fan. Make sure the flow sensor is in its proper position, not damaged, that the connected hose is in good condition, and that the holes in the sensor are not blocked.
    b. If there is a problem with the fan or the flow sensor, contact the manufacturer before further use.
    c. Digital pressure gauges should be calibrated according to the manufacturer recommendations.
    d. For detailed maintenance recommendations, check with the manufacturer.
2. Deactivate all vented combustion appliances before depressurizing the structure by turning the thermostat down, or by deactivating all combustion appliances.
3. Prevent the ashes of wood- or coal-burning units from entering the habitable space by closing and sealing doors and dampers, by cleaning out the ashes, or covering them.

4. Inspect the house for loose or missing hatchways, paneling, ceiling tiles, or glazing panes. Secure any items that may become dislocated during the test and seal any missing hatchways.
5. Close all primary windows, self-storing storm windows (if possible), skylights, and exterior doors and latch them in the position they normally would be found during the winter.
6. Open all livable areas to the interior of the structure, even if the occupants close them off during the winter.
7. If the basement is defined as a part of the thermal/pressure envelope, determine the CFM_{50} value with the blower door with the basement door open. If the basement is defined as not part of the thermal envelope (conditioned space), the blower door test should be done with the basement door closed.
8. Set up the blower door unit in an exterior door opening in an area free from obstructions and wind interference.

14.1.2 Blower Door Test, Depressurization (typical)

1. Set up the blower door in an exterior door that has the least number of obstacles within 3 feet of the blower door fan. If the doorway leads to an enclosed area, make sure the space is open to the outdoors. Do not set up in a door facing the wind if an acceptable alternative exists.
2. Install the frame and panel securely into the doorframe, making sure there are no gaps between any of the components or between the components and the doorframe.
3. Set the fan into the panel/frame assembly, making sure that the panel opening fits snugly around the fan. Install the fan so that the flow-ring assembly is facing toward the inside of the house. Set up the fan in a level, or nearly level, position.
4. Make sure the blower door variable speed control is in the off position. Plug the fan electric cord into a safe and fully functional electrical outlet.
5. Set up the digital manometer correctly for the required testing.
6. Perform a one-point test by depressurizing to -50 Pascals or, if unable to reach -50 Pascals, the highest possible negative house pressure. Digital manometers may have automatic adjustments for “can’t reach 50”; these numbers may be used for the CFM50 test results. Use fan rings or plugs as necessary. If wind seems to be affecting the test results, take several one-point tests and average the results.
7. See the manufacturer’s instruction manual for other details of depressurization testing.

14.1.3 Blower Door Test, Pressurization

1. Use a pressurization blower door test only if a drip-pot oil-burning space heater is in operation or for some other reason approved by the MaineHousing.

2. Install the door frame and fabric as it is normally done for a depressurization test.
3. The blower door fan must be installed so that the inlet side of the fan (the side with the flow sensor and rings) faces outdoors. If your fan has a fan-direction switch it must be set to blow air into the dwelling.
4. Level and stabilize the fan as necessary.
5. Set up the digital gauge correctly and find the baseline pressure.
6. Perform a one-point test by pressurizing to 50 Pascals or, if unable to reach 50 Pascals, the highest possible house pressure. Use fan rings or plugs as necessary. If wind seems to be affecting the test results, take several one-point tests and average the results.
7. See the manufacturer's instruction manual for other details of pressurization testing.

14.2 Air Sealing Target (AST) and Air Sealing Limit (ASL)

MaineHousing recognizes that cost-effective air sealing procedures with the incremental use of a blower door and computer software is the best way to determine when to continue and when to stop air sealing a dwelling.

When this method is not used, the crew or contractor performing the air sealing work should tighten to the dwelling Air Sealing Target (AST) CFM_{50} or lower. The AST is determined by dividing the *above-grade* volume within the thermal/pressure envelope by 10. For example, if the volume of the above-grade thermal/pressure envelope is 12,000 ft^3, the AST is 1200 CFM_{50}.

The AST CFM_{50} shall correspond with the standard method of determining the blower door test volume. For example, if a basement or crawl space is defined as being within the thermal/pressure envelope, for the pre- and post-weatherization blower door tests (as well as those done during air sealing) the basement or crawlspace should be open to the main part of the dwelling during testing.[16] The lowest AST used in the Maine WAP shall be 1000 CFM_{50}.

The Air Sealing Limit (ASL) shall be the higher of the:

1. Air Sealing Target (AST) CFM_{50}, or 1,000 CFM50
2. If the dwelling ends up tighter than the Air Sealing Limit (ASL), ensure that:
3. All combustion appliances are drafting properly and not spilling (see Section 5.8 for worst-case depressurization testing details); and
4. Minimum ventilation for acceptable indoor air quality is installed in accordance with ASHRAE 62.2-2016. See Section 4.16.

[16] For example, if the above grade house volume is 12,000 ft^3, which includes a basement with an average height of two feet above grade, the AST is 1200 CFM_{50}. This volume measurement should not include the part of the basement that is below grade. When performing blower door testing in an attempt to air seal to this 1200 CFM_{50} AST, the basement door should be open. This open basement door includes the above- and below-grade volume of the basement.

14.3 Depressurization Tightness Limit (DTL)

If the dwelling has atmospheric combustion appliances, MaineHousing recommends the Depressurization Tightness Limit (DTL) be calculated before weatherization work begins.

The DTL calculation establishes a CFM_{50} minimum, below which the back drafting of open-combustion appliances is likely to occur. This limit provides a guideline for air sealing activities.

If the energy auditor expects exhaust fans will be added to the dwelling in order to comply with ASHRAE 62.2-2016, an estimate of the CFM fan flow of these added fans should be included in this procedure.

The use of the DTL should never be used as a substitute for performing the worst-case depressurization test procedure after all weatherization work is completed.

14.3.1 DTL Procedure

1. Use the values in Table 14-1, Exhaust Appliance Nominal CFM, if the measured CFM flow rates of exhausting appliances (exhaust fans, dryer, whole-house vacuum, etc.) are not known. Measuring for actual CFM flow rates is preferred. Include any appliances that are not yet installed, but will be during weatherization work. For example, include the CFM exhaust rate of an electric or gas dryer that is not vented to the outdoors now, but will be vented as part of your weatherization work.

Table 14-1

Exhaust Appliance Nominal CFM	
Appliance	***CFM Nominal***
Bathroom exhaust fan	50
Kitchen range hood	100
Kitchen wall fan	250
Kitchen down-vent fan (Jenn-Air)	300 – 600
Dryer	180
Central vacuum	150
Fireplace	200 – 400
Gas/Oil water heater	70
Wood stove, not airtight	100
Wood stove, airtight	10
Note: Actual CFM might be significantly less than nominal – or rated – CFM.	

2. Select appropriate value in Table 14-2, Combustion Appliance Depressurization Limits. If more than one appliance is located in a combustion appliance zone (CAZ), use the appliance depressurization limit most likely to backdraft. For example, an appliance with a rating of -2 Pascals is more likely to backdraft than an appliance rated at -5 Pascals.

3. Use the Depressurization Values chart, included at the end of this document, to determine the DTL.

Table 14-2

Combustion Appliance Depressurization Limits	
Appliance Type	***Maximum Recommended***
Appliances with manufacturer certified negative pressure tolerance rating	The manufacturer-certified negative pressure tolerance rating
Atmospheric water heater not common vented (Category I, natural draft), open-combustion appliances	-2
Atmospheric water heater (Category I, natural draft) common vented atmospheric furnace (Category I, natural draft or Category I, fan assisted), open-combustion appliances	-3
Gas furnace or boiler, Category I or Category I fan-assisted, open-combustion appliances	-5
Oil or gas unit with power burner, low- or high-static pressure burner, open combustion appliances	-5
Closed, controlled wood-burning appliances	-7
Induced-draft appliances (fan at point of exit at wall), Category I with induced draft, open-combustion appliances	-15
Pellet stoves with exhaust fans and sealed vents	-15
Gas appliances, Category III or Category IV, vented through the wall, forced draft, open-combustion appliances	-15
Direct-vent, sealed combustion appliances with forced draft	-25
Adapted from Minnesota Energy Code 7672.0900 and Canadian General Standards Board 51.71.	

The Depressurization Tightness Limit CFM_{50} is primarily a dwelling tightening guideline ~~limit~~ for combustion safety. Use this as a reference when estimating the low CFM50 target to house tightening. For example, if the DTL is 1600 CFM_{50}, the Auditor may use that as the air tightening target CFM50, and instruct the crew or contractor not to tighten to below 1600 CMF_{50}. See Section 5.2 for detailed guidance regarding house tightening.

The DTL is a tightening guideline only; it must never be used to replace real-time combustion safety testing.

14.4 Air Handler Pressure Balance Testing

This test procedure is performed only in dwellings with central air handlers (furnaces and/or air conditioners). Room-to-room pressure(s) should be measured in all rooms with forced air heating return or supply ducts and operable doors, *after all weatherization work has been completed, but before the worst-case depressurization test is performed*. The procedure indicates the magnitude of:

1. Duct leakage to the outdoors, either through supply or return ducts.
2. Imbalances of air distribution resulting from closed interior doors. These closed doors can act as dampers to the free flow of air within the conditioned space of the dwelling.
3. Imbalances of air distribution resulting from airflow differences between the supply side and return side of the ductwork. Such an imbalance could result from a restricted return trunk, for example.

   Such pressure imbalances can result in increased air leakage to and from the outdoors when the air handler is running.

14.4.1 Whole House Test Procedure

1. Set up the house in blower door test mode (the blower door is not used for this test).
2. Run a pressure hose from the main body of the house to the outdoors.
3. Record any pressure difference between the main body of the dwelling and the outdoors. This is the reference baseline pressure.
   a. A reference baseline pressure might be due to stack-effect air leakage (especially if it is cold outdoors) or wind.
4. Turn on the air handler and measure the pressure of the main body of the house with reference to the outdoors.
   a. If the pressure difference between the main body and the outdoors is different with the air handler on than with the air handler off, there is probably some duct leakage to the outdoors:
      i. Either from the return side of the system (the pressure difference of the dwelling with reference to outdoors will move toward positive when the air handler is activated), or
      ii. From the supply side of the system (the pressure difference of the dwelling with reference to outdoors will move toward negative when the air handler is activated).
5. Close all interior doors.
6. Repeat the pressure measurement from the main body of the house with reference to the outdoors.
   a. If this pressure is different than it was when all the interior doors were open, the interior doors are acting as dampers to the air distribution system. This can cause thermal discomfort and stuffiness in the room and it can increase the air leakage to and from the outdoors when the air handler is running.

14.1.2 Room-to-Room Test Procedure

1. With a digital pressure gauge measure the pressure difference across all interior doors while the air handler is operating and the house is set up in blower door test mode (the blower door is not used for this test). Record measurements for all rooms with reference to the main body of the house. Make sure that registers and grilles are not blocked, even though they appear open. Provide pressure relief to any room with readings greater than three Pascals by:
    a. Opening the door slightly while measuring the pressure difference across the door. Open the door until the pressure difference is less than three Pascals and measure the square inches of the opening. This is the number of square inches:
        i. By which the door must be undercut (this usually works well in manufactured homes) to reduce the pressure difference across the door to an acceptable amount.
        ii. Of the cross sectional area of a direct grille, offset grille, or jump duct that must be installed to properly relieve the pressure imbalance caused by the distribution system when the door is closed.
2. Turn off the air handler and return the house to the condition it was in before testing began.

14.5 External Static Pressure Testing

If the external static pressure (ESP) is too high, the airflow might be blocked or the ductwork might be too small or restricted. The higher the ESP, the lower the airflow within the ductwork. If the ESP is too low, the ductwork might be very leaky or the blower might be dirty or working improperly.

Typical ESP values are from 0.5 IWC or 125 Pascals with an air-conditioner coil and filter and from 0.25 IWC or 62 Pascals without an air-conditioner coil and filter.

1. Find the manufacturer's recommended external static pressure value on the name plate of the unit. It is likely that this value will be in units of Inches of water column, rather than Pascals. Record this recommended value; it is the combined values of the supply-side and return-side static pressures, ignoring the negative sign of the return-side static pressure.
2. Make sure the furnace filter is in place. A clean filter is preferred.
3. With a static pressure tip connected to your digital manometer, measure both the supply- and return-side static pressure at the outlet and inlet of the blower by drilling measurement holes in the supply and return ductwork.
    a. In order to avoid turbulence, take readings 3 to 5 duct diameters downstream of the air handler blower.
    b. Don't measure air conditioning coil unless it shipped with the original unit. On some jobs, this will be difficult to determine. In all cases, document whether you measured the static pressure of the air conditioning coil or not.

i. To measure the air-conditioning coil static pressure, the hole for the static pressure tip connected to your digital manometer must be located downstream (after) of the air-conditioning coil. Take care that the coil is not damaged by your activities.

ii. To ensure that you are not measuring the static pressure of the air-conditioning coil, locate the test hole upstream (before) the air-conditioning coil. Take care that the coil is not damaged by your activities.

4. Add the supply- and return-side static pressures together – ignoring the negative sign of the return side pressure – to find the total external static pressure.

   a. This total ESP should fall within the range of the manufacturer's recommendations on the appliance label. If it does not, correct the problem and retest. This test could be performed by a licensed tech as part of a CT&E and corrections made prior to weatherization.

   b. It is preferred that the supply- and return-side static pressure values are of similar magnitudes. Restricted returns, usually undersized, are a common problem with ducted distribution systems. The energy auditor or heating system technician must determine if a restricted return should be repaired or not.

5. Patch all test holes with an appropriate material.

14.6 Temperature-Rise Measurement

Excessive temperature rise can result from low air handler fan output (wrong fan speed, bad motor bearings, low voltage, dirty blower, wrong fan rotation, slipping or broken fan belt); low airflow from restrictions in ductwork; or an over-fired burner. Low temperature rise can result from excessive fan speed, excessive duct leakage, or an under-fired burner.

The temperature rise should be within the range specified on the manufacturer's label, or between 40^{o} and 80^{o}F.

14.6.1 Setup and Testing

Look for the appropriate manufacturer's temperature rise on the name plate of the unit.

1. *Up-flow furnaces* (these are typically found in basements or closets):

   a. *Supply side:* Drill a hole and insert the thermometer in the supply plenum as close as possible to the heat exchanger, but "out of sight" of the heat exchanger (this ensures that the reading will not be affected by radiant thermal energy from the heat exchanger). If the furnace plenum houses a central air conditioning coil, be very careful to avoid damaging this coil. Drill the hole beyond the cooling coil.

   b. *Return side:* Drill a hole and insert the thermometer into the return plenum approximately 2 feet before the filter. Where an integral humidifier with a crossover duct is present, drill the hole before the crossover duct from the supply plenum so that the temperature is not affected by the warmer air in the crossover duct.

c. Subtract the return air temperature from the supply air temperature. The difference is the temperature rise.

2. *Horizontal-flow furnaces* (these are typically found in crawl spaces or attics):

   a. Drill a hole and insert the thermometer in the supply plenum as close as possible to the heat exchanger, but “out of sight” of the heat exchanger (this ensures that the reading will not be affected by radiant thermal energy from the heat exchanger). *Return side:* Drill a hole and insert the thermometer into the return plenum approximately 2 feet before the filter.

   b. Subtract the return air temperature from the supply air temperature. The difference is the temperature rise.

3. *Down-flow furnaces* (these are typically found in manufactured homes). The furnace compartment door should be closed while taking the temperature readings. The instructions below assume a living space return system, rather than a belly return system.

   a. Inspect and, if necessary, repair the plenum/furnace joint before measuring the temperature rise.

   b. Make sure all interior doors are open, including the furnace closet door.

      i. The furnace closet door should be a louvered door.

   c. Turn on the furnace and allow the temperature of the supply air to stabilize. Measure the temperature at the register closest to the furnace – supply air temperature – making sure that the airflow to this register is not blocked and that there is no significant duct leakage between the furnace and your thermometer.

   d. Subtract the return air temperature from the supply air temperature. The difference is the temperature rise.

      i. Test the return side air temperature by placing the thermometer probe at or through the slots in the blower compartment cover near the top of the furnace.

4. Upon completion of testing, patch all holes with an appropriate material.

14.6.2 Analysis and Solutions

1. If the temperature rise is greater than the recommended range, the airflow is probably being restricted by:

   a. An undersized opening in the furnace closet door, or

   b. Undetected restriction in the ductwork.

2. If the temperature rise is less than the recommended range, there might be:

   a. Significant leakage at the furnace/plenum joint, or

   b. Significant leakage in the duct between the furnace and the location of your supply air temperature measurement.

3. If the temperature rise is out of range, repair the cause of the problem. Check the temperature rise again. This test could be performed by a licensed tech as part of a CT&E and corrections made prior to weatherization.

14.7 Pressure Pan Testing Procedures for Manufactured Homes[17]

Pressure pan testing helps find ductwork leaks or disconnections that are connected to outdoor air. Testing before and after duct sealing gives an indication of the effectiveness of duct sealing efforts. Pressure pans do not read duct leakage directly; they infer leakage to the outdoors by reading the pressure at individual registers. Refer to Section 2.1.1.2 for specific manufactured home duct leakage standards.

14.7.1 Test Procedure

1. Install the blower door for a depressurization test. Make sure the dwelling is set up for winter conditions.
2. Open all interior doors.
3. Make sure the furnace burner and air handler are off and will not start during the testing.
4. Remove the furnace filter for the pressure pan test. Remember to replace the filter upon completion of the testing.
5. Temporarily seal outside combustion air inlets or ventilation system connections that are directly connected to the duct system. These connections will show up as large leaks if not sealed prior to testing. Remember to remove any material used to seal these inlets once testing is complete.
6. It is recommended to open skirting under the manufactured home to the outdoor air.
7. Only one person at a time should be taking pressure pan readings. Having two registers in different parts of the duct covered by a pressure pan at the same time might affect readings.
8. Depressurize the dwelling to -50 Pascals with the blower door.
9. Make sure the pressure pan is properly connected to the manometer. The proper connection should be reading the space under the pressure pan with reference to the main dwelling pressure.
10. Place the pressure pan completely over each register and grille in conditioned areas.
    a. If a register or grille is larger than the pressure pan, cover the oversized portion of the register or grille with tape while the reading is recorded.

[17] This section is primarily based on *Using a Pressure Pan to Diagnose Duct Leakage* by the Energy Conservatory, April 2010. This document is available on the Internet at http://www.energyconservatory.com/download/presspanuser.pdf.

b. If access to a register or grille is difficult, for example duct registers mounted to the outside walls or a kitchen counter kick space, cover the entire opening with tape and insert the pressure probe through the tape (near the center of the taped opening) while the reading is recorded.

c. When two registers or grilles are closely connected to the same duct run (for example, two registers on opposite sides of the same partition wall), seal one and use the pressure pan on the other unsealed register or grille. Once you have taken the pressure pan reading, remove the seal before proceeding to the next register.

11. Record the pre and post pressure pan readings on the MaineHousing field form. It will sometimes be useful to record readings during duct sealing. Make sure recorded measurements are clearly labeled for subsequent test comparison.

12. If you are testing a manufactured home with a very leaky building shell and are not able to create a -50 Pa pressure difference with the blower door, perform your pressure pan tests with the dwelling at the highest achievable pressure. In this case, you will need to interpret your pressure pan readings carefully. Compare the measured pressure pan reading with the maximum possible reading.

14.8 Worst-Case Depressurization Testing

The purpose of worst-case depressurization testing is to ensure the proper venting of all vented combustion devices in a dwelling. This testing must always be done before and after all other weatherization work has been completed. MaineHousing strongly encourages that testing be completed by a trained individual at the end of every work day before the workers leave the site.

The Depressurization Tightness Limit (DTL) should also be calculated before weatherization work begins. The DTL is a CFM_{50} estimate that is used as an air sealing guideline. If the dwelling is tightened to a CFM_{50} value that is less than the DTL, backdrafting may occur. The DTL must never be used as a substitute for worst-case depressurization testing.

The worst-case depressurization test measures the pressure difference between the outside and inside of the house at the combustion appliances in the combustion appliance zone (CAZ). This measurement will confirm whether there is adequate draft for the vent system of all open-combustion appliances. If a house contains more than one CAZ, a worst-case depressurization test must be performed for each area.

14.8.1 Dwellings Requiring Worst-Case Depressurization Testing

1. Worst-case depressurization testing must be done in all dwellings before and after all other work has been completed in all units that were weatherized.

2. The following are exceptions to this requirement:

   a. If the house or manufactured home is all-electric with no combustion appliances, woodstoves or fireplaces, or has appliances that are all sealed combustion

(direct vent) or unvented (vent free), a worst-case depressurization test does not have to be performed.

b. In apartments with no combustion appliances other than unvented or direct-vent combustion appliances, a worst-case depressurization test does not have to be performed.

14.8.2 Test Procedure

1. "Worst-case" is defined as the configuration of the house that results in the greatest negative pressure *in the combustion appliance zone* (CAZ).
2. Consideration must be given to:
   a. The types and locations of the heating systems.
   b. The location and CFM rating of all exhausting equipment (bath fans, dryers, kitchen exhaust devices, etc.).
   c. The location of wood stoves, fireplaces, and water heaters.
   d. The volume of the area where the combustion devices are located.
   e. The location of forced-air system returns.

14.8.3 Procedure Setup

1. Place the building in the wintertime condition with all windows and exterior doors closed. If it is not practical to close or install existing storm windows, latch or lock primary window units. If the blower door is set up, make sure the fan is closed off.
2. Record the outdoor temperature on the approved form. Other information should also be recorded on this form during the test procedure.
3. Deactivate all combustion appliances by turning them off or setting the control to "pilot."
4. Close all operable vents (for example, a fireplace damper).
5. If there is a furnace, replace or clean the filter if it is dirty.
6. Check and clean the lint filter in the dryer.
7. Set up pressure hoses so that the pressure differential of the CAZ with reference to the outdoors can be easily measured with a digital manometer. If the CAZ is in a basement, run a pressure hose to the outdoors through a window or door, and then close the window or door as tightly as possible without totally closing off airflow through the hose.

With the interior doors in the conditioned area open and all combustion appliances and exhaust devices off, record the baseline pressure in the CAZ. This is the pressure in the CAZ resulting from stack-effect air leakage. Generally, the colder the outdoor temperature the greater the magnitude of this baseline value. Most digital manometers have a feature that accounts for baseline pressure by pressing "enter" when the baseline pressure is stable. Otherwise, record the baseline pressure before proceeding.

14.8.4 Determining Worst-Case Conditions

1. Turn on all exhaust devices (except a whole-house exhaust fan) and record the pressure in the CAZ. The pressure created in the CAZ from the operation of these exhaust fans is the difference between this value and the baseline pressure measured in step 0 above.

    a. Working Fireplaces: The potential effect of working fireplaces should be considered when determining worst case depressurization. It is difficult to estimate the potential cfm draw of any working fireplace, however, simulating a fireplace at 300cfm is an accepted guideline. Weatherization staff are encouraged to inform clients that fireplaces are a net energy loss and potential combustion safety hazard, and to encourage them to allow permanent sealing of fireplaces, when feasible, as part of the weatherization strategy for the home.

        i. Simulation of a fireplace at 300cfm is required when:

            (1) Combustion Safety test results in worst case without the fireplace include:

            (2) Spillage exceeds 1:45 minutes (warm vent) or 4 minutes (cold vent).
            (3) Undiluted CO in the appliance vent exceeds 100ppm as measured or 200 ppm air-free.
            (4) Ambient CO exceeds 3 ppm.
            (5) The thermostat is located outside the room where the fireplace is located.

    b. The energy auditor or inspector considers it prudent to do so based on their assessment of the house as a system and/or occupant behavior. *Note: If there is a whole-house exhaust fan, it is important to inform the client that operating this fan with the house closed up could be very hazardous.*

    c. If the house contains a furnace, activate the blower. Record the pressure reading in the CAZ with reference to the outdoors. *Caution: If the only way to activate the blower is to fire the furnace, extreme caution must be used due to the potential for combustion back drafting or flame rollout. Try to activate the furnace blower without firing the furnace burner.*

2. Close each interior door and measure the pressure difference between the main body of the house and the room you are closing off when standing on the main-body side of the door with your digital pressure gauge. If the pressure in the closed room is negative relative to the main body of the house, leave this door open. If this pressure is positive, close this door.

    a. Note: Room-to-room pressure testing and adjusting should have been completed before this worst-case depressurization test is performed. Refer to Section 6.4 and Section 5.4.3 for this test.

    b. For this step, there are some underlying assumptions:

        i. The main body of the house is connected to the CAZ being tested.

ii. If the house has a ducted distribution system, the air handler blower is operating.

iii. All exhaust appliances in the house, except a whole-house fan, are running.

3. Close the door to the CAZ (this is usually the basement door). If closing this door results in greater depressurization in the CAZ with reference to the outdoors (for example, closing the door changes the pressure from -2 to -4), leave this door closed. If closing this door decreases the depressurization (for example, closing the door changes the pressure from -4 to -3), leave this door open.

4. Determine whether the furnace air handler fan contributes to depressurization. This is done by turning the air handler fan off and then on again while watching the CAZ pressure with reference to outdoors.

5. Record the net worst-case depressurization; that is, the negative pressure of greatest magnitude in the CAZ with reference to outdoors after subtracting the baseline CAZ pressure, unless using the baseline feature on the digital manometer.

14.8.5 Worst-Case Depressurization vs. Appliance Depressurization Limit

Compare the net worst-case depressurization with the appliance depressurization limits in Table 14-2, Combustion Appliance Depressurization Limits, in Section 5.3.2, Combustion Appliance Depressurization Limits

1. If the actual net worst-case depressurization is equal to or more negative than the appliance depressurization limit value in Table 14-2:

   a. Select the appropriate option in Section 0, number 6.or

   b. Replace the affected appliance with one that is more resistant to depressurization (for example direct-vent, sealed combustion appliance);

   c. If options a. and/or b. above will not alleviate the problem, deferral of services may be warranted. See Section 4.7.

14.8.6 Verifying Proper Appliance Venting

1. Monitor ambient carbon monoxide levels during this testing. If levels reach 35 ppm or greater, stop the testing and dilute the ambient air with outdoor air. Before testing continues, the source of this CO must be mitigated.

2. Under these worst-case conditions, fire the combustion appliance with the lowest Btu input first. Check for spillage after two minutes of firing. If the appliance spills after two minutes, it fails the spillage test.

3. For oil-fired appliances, conduct a smoke test when steady state is reached. A smoke test greater than 2 indicates the appliance needs cleaning and tuning. In this case, do not continue with steady state combustion efficiency testing; a CT&E must be ordered.

4. After the appliance reaches steady-state (stable temperature in the vent connector), measure the CO in the vent connector of the appliance, ensuring that there is no room dilution air at the point of measurement. The CO value must be less than 200 ppm as-measured or 400 ppm air-free.
    a. If the CO levels are higher, the appliance must be cleaned and tuned and then retested for CO, unless the CO measurement is within manufacturer specifications.
    b. If all readings are within acceptable ranges, it is an opportune time to measure the steady-state efficiency of the appliance with the combustion analyzer.
5. Fire all remaining appliances, one at a time, in order of input rating (smaller to larger), testing each one for spillage and draft. All appliances must achieve acceptable spillage and draft tests.
    a. If the appliances vent into the same chimney flue or vent connector, test each one individually.
    b. If the appliances vent into different chimney flues or vents, test with each successive unit running, that is, as you fire up the next appliance, allow the previous one to operate.
6. If spillage is unacceptable, correct the problem by one of the following methods (listed in order of preference):
    a. Check for blockage in the vent system and, if found, correct the problem;
        i. As a simple test to determine if the unacceptable spillage or draft test is caused by blockage or excessive negative pressure in the CAZ, open a window or door in the CAZ so that it is well connected to the outdoors. If the cause is for the bad draft or spillage is negative pressure, this will relieve the negative pressure, allowing the vent system to work properly. On the other hand, if the problem is caused by a restriction in the vent, the spillage/draft problem will remain. Keep in mind that there is the possibility that the venting problem could be the result of a blockage *and* excessive negative pressure in the CAZ.
    b. Inspect ducted distribution systems for return leakage in the CAZ. Seal any leakage to make the net worst-case depressurization less severe. Inspect ducted distribution systems for supply leakage in places other than the CAZ. Seal any leakage to make the net worst-case depressurization less severe.
    c. Increase the CAZ air volume by connecting the CAZ to other areas within the conditioned volume of the dwelling (see NFPA 54, NFPA 31, or NFPA 211);
    d. Duct outdoor air directly to the burner's combustion-supply air port; or
    e. Increase the CAZ air volume by connecting the CAZ to the outdoors (see NFPA 54, NFPA 31, or NFPA 211).

f. Supply outdoor air to the CAZ with a supply fan linked to the affected combustion appliance controls.

g. For technical assistance, consult a fully licensed technician and/or MaineHousing.

7. If the dwelling has other combustion appliance zones, repeat the sequence of activating exhaust equipment, door closure, furnace blower activation, recording pressure readings, etc.

8. When all worst-case depressurization testing has been completed, turn off all exhaust equipment and return doors and combustion appliances to their previous operational settings.

14.9 Zone Pressure Diagnostics (ZPD) Testing

Zone pressure diagnostics testing is performed to answer some fundamental questions. Where is the functioning air barrier and how leaky is it? These test procedures can also be used to measure the size of the leakage paths to various house zones. Leaking air often takes a path through pressure boundaries that have a cavity, or zone, between them. These zones can include attics, basements, garages, knee-wall areas, or attached porch roofs.

ZPD testing is utilized in cases where additional information is needed regarding the relative and absolute leakage of air barriers (pressure boundaries). These standards recommend ZPD testing for (refer to Sections 6.5 and 7.2.6 for details):

1. Verifying the effectiveness of attic air sealing, and determining the amount of air leakage between an attached or tuck-under garage, and then confirming that air leakage has been reduced to acceptable levels by weatherization measures.

   ZPD procedures require the measurement of *pressure differences* across air barriers, like the pressure difference between the house and the zone (attic, for example), while the house is depressurized or pressurized by a blower door. The procedures can also determine *flows* across air barriers. These flows can be calculated by capturing ZPD data on a printed worksheet or on-line software. Once these flows are calculated, an estimate of the square inches of leakage through an air barrier can be determined.

   These procedures can be used with primary and secondary zones. Primary zones are zones to which you have access, such as basements or attics. This access allows you to open a temporary hole or door between the zone and the dwelling or between the zone and the outdoors. For primary zones, ZPD may be conducted because of:

   1. Air leakage/energy loss concerns. If, after initial tightening of large leaks, the house still has significant, but not obvious, air leakage, performing ZPD can help identify whether the leaks are in the attic floor, the house walls, or through the basement or crawl space walls.

2. Indoor Air Quality concerns. Examples include air movement from attached or tuck-under garages into a living area, and moisture or soil gas movement from a crawl space into the dwelling.
3. Attics with potential or actual moisture-related problems. This might be the case if:
    a. The attic has obvious moisture problems,
    b. The dwelling has evidence of high relative humidity in winter, or
    c. Ice dams are a concern.
    d. Secondary zones are zones to which you have no access, such as porch roofs. This lack of access prevents you from creating a temporary hole between the zone and the dwelling or the zone and the outdoors. Because of this, you cannot determine the flow between secondary zone and the dwelling or outdoors. However, if you are able to insert a pressure hose into the zone, you can measure the pressure difference between the zone and the dwelling or outdoors. Knowing these pressure differences can be helpful at times.

14.9.1 Test Procedures

1. Use the Residential Energy Dynamics, LLC free software, RED Calc Free ZPD Zone Pressure Diagnostics tool, available on line or other MaineHousing approved methods for these tests.
2. Perform the whole-house blower door test before doing any zone pressure diagnostics (ZPD) testing.
    a. If you cannot reach a house pressure difference of 50 Pascals and/or there are obvious large leaks, repair large leaks before any ZPD testing. ***You must be able to reach a house pressure difference of 50 Pascals in order to do basic ZPD testing, before you create a temporary hole for the add-a-hole test.***[18]
    b. If you can reach a house pressure difference of 50 Pascals, but the house is relatively loose for its size, find and seal large leaks before performing ZPD testing.
    c. ***If the house is relatively tight for a dwelling of its size, there is probably no reason to perform basic ZPD testing for energy reasons.*** However, there might be reason to perform testing for moisture or indoor air quality concerns, such as testing the common wall between the house and an attached garage. In these cases, using a smoke pencil on the garage/attic side of the common barrier while depressurizing the house to -50 Pascals can illustrate leaks in the air boundary.

[18] Advanced zone pressure diagnostics procedures do not require a house pressure of 50 Pascals.

3. Identify zone types. ZPD can be done on all primary zones including attics, crawl spaces, basements, and attached or tuck-under garages. ZPD can also be done on some secondary zones, such as porch roofs and cantilevers, which will be sealed off from the house.
4. Useful testing can include from house to attic and from house to attached or tuck-under garages. See Section 6.5 for details.
5. For primary zone ZPD testing, perform the add-a-hole or open-a-door test using the RED Calc Free ZPD Zone Pressure Diagnostics tool or printed MaineHousing Zone Pressure-Series Leakage Diagnostics chart, respectively. The following steps are for the add-a-hole test:
    a. Set up the blower door for building depressurization.
    b. With a separate digital ZPD manometer, in default Pr/Pr mode, located in the main body of the house, run a pressure hose from the right-hand input channel (upper right tap) to the zone you are testing (try to use a blue hose). Run another pressure hose from the house to the outdoors on the left-hand channel reference tap (lower left tap - try to use a green hose).
    c. Depressurize the building to – 50 Pascals on the blower door manometer (read this pressure from the left -hand pressure screen).
    d. On the ZPD manometer, read the right-hand pressure screen.
    e. Measure, record, and enter the pressure from the zone WRT outside On the ZPD manometer, remove the pressure hose (green) from the lower tap on left-hand channel.
    f. With the hose on the upper right tap, measure, record, and enter the pressure from the zone to the house that shows on the right -hand pressure screen.
    g. Determine where a temporary hole will be created – either between the building and the zone, or between the zone and the outdoors.
    h. Enter the location of the created hole in the RED software – either in the building-to-zone air barrier, or in the zone-to-outdoor barrier.
    i. It is best to lower the air barrier pressure difference where the hole is added by 15 or more Pascals.
    j. Make certain that the house-to-outdoor pressure is brought back up to -50 Pascals, on the blower door manometer, when the temporary hole is open*. If you are not able to bring the house-to-outdoor pressure up to fifty, you must abort the ZPD test.*
    k. On the ZPD manometer, the hose to the zone is on the top right tap while the bottom right tap is open to the house pressure (-50 Pascals). With the temporary hole open and the building-to-outdoor pressure difference at 50 Pascals, measure, record, and enter the pressure from the building to the zone.

l. On the ZPD manometer, reconnect the green outside pressure hose to the lower left tap.

m. With the temporary hole open and the building-to-outdoor pressure difference at -50 Pascals, measure, record, and enter the pressure from the zone to the outdoors seen in the right screen.

n. With all the input data entered in the calculator, press “ENTER” for the calculation of the answers.

o. Record the three answers: the building-to-zone CFM_{50}, the zone-to-outdoor CFM_{50}, and the total path CFM_{50}. Dividing the first two numbers by ten gives an approximation of the square inches of leakage in the respective air barriers.

p. Based on the ZPD results, air seal as necessary.

q. During or after air sealing, perform add-a-hole ZPD to determine the effectiveness of the weatherization work.

6. The RED software will also assist in performing the open-a-door method of ZPD. The door method is faster when determining the leakage between a house and attached garage. MaineHousing recommends using the door method for this test.

7. For secondary zone testing:

   a. It is not necessary – or possible – to perform an add-a-hole or open-a-door test; only pressure testing is required. Therefore, it is not necessary to use the RED software. There are significant limitations to the diagnostic accuracy of secondary zone testing.

15 Glossary

- A -

Abatement – A measure or set of measures designed to permanently eliminate a hazard (e.g., lead-based paint). Abatement strategies include removal of the hazardous materials, replacement of building components containing the hazardous material, enclosure, or encapsulation. All of these strategies require proper preparation, cleanup, waste disposal, post-abatement clearance testing, and if applicable, record keeping and monitoring. Abatement activities are not allowable expenses to be funded by Department of Energy Weatherization Assistance Program dollars.

Absorption – Absorption is the process by which a substance can be readily taken into the body through the skin or membranes. The best defense is to have a protective barrier between the substance and the skin.

Air Changes per Hour at 50 Pascals (ACH_{50}) – The number of times that the complete air volume of a home is exchanged for outside air in one hour when a blower door depressurizes or pressurizes the home to 50 Pascals.

Air Changes per Hour Natural (ACH_{nat}) – The number of times the indoor air is exchanged with the outdoor air in one hour under natural driving forces. It can be estimated using a blower door.

Air Exchange – The process whereby indoor air is replaced with the outdoor air through air leakage and ventilation.

Air-Free Carbon Monoxide – A measurement of CO in an air sample or flue gas that takes into account the amount of excess air (oxygen, O_2) in the sample, incorporating an adjustment to the as-measured CO ppm value, thus simulating air-free (oxygen-free) conditions in the sample. Usually measured in units of parts per million (ppm). See *As-Measured Carbon Monoxide*.

Air Handler – A steel cabinet containing a blower with cooling and/or heating coils connected to ducts, which circulates indoor air across the exchangers and into the habitable space.

Air Infiltration Barrier – A spun polymer sheet (for example, house wrap) that stops almost all the air traveling through a building cavity, while allowing moisture to pass through it.

Air Sealing Limit (ASL) – The house tightening CFM_{50} limit determined by selecting the higher of the Air Sealing Target (AST) and 1000cfm50

Air Sealing Target (AST) – The AST is a CFM_{50} value determined by dividing the *above-grade* volume within the thermal/pressure envelope by 10. For example, if the volume of the above-grade thermal/pressure envelope is 12,000 ft^3, the AST is 1200 CFM_{50}. The AST CFM_{50} shall correspond with the standard method of determining the blower door test volume. For example, if a basement or crawl space is defined as being within the thermal/pressure envelope, for the pre- and post-weatherization blower door tests (as well as those done during air sealing) the basement or crawlspace should be open to the main part of the dwelling. The lowest AST used shall be 1000 CFM_{50}.

Altitude Adjustment – The input modification for a gas appliance installed at a high altitude. When a gas appliance is installed more than 2000 feet above sea level, its input rating must be reduced by approximately 4 percent per 1000 feet above sea level.

Ambient Air – Surrounding conditions. Usually refers to the air around a combustion appliance.

Ampere – A unit of measurement that tells how much electricity flows through a conductor. It is comparable to a cubic foot per second measurement of water flow. For example, a 1,200-watt, 120-volt hair dryer pulls 10 amperes of electric current (watts divided by volts).

AFUE – Annual Fuel Utilization Efficiency – A laboratory-derived efficiency for heating appliances that accounts for chimney losses, jacket losses, and cycling losses, but not distribution losses or fan/pump energy use.

Appliance Depressurization Limit – This is a selected indoor negative pressure. It is expressed in Pascals and measured in the immediate area around vented combustion appliances that use indoor air for combustion supply air. If a combustion appliance experiences a negative pressure of a greater magnitude than this limit, it has the potential to backdraft, causing a hazardous condition for the occupants. See Table 14-2 for these limits.

Aquastat – A heating control that switches the burner or the circulator pump in a hydronic heating system.

Asbestos – A fibrous mineral with fireproof and insulation characteristics which may be shaped into a variety of building materials. Small, sharp, asbestos fibers may cause damage to lungs if they are inhaled.

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

As-Measured Carbon Monoxide – A measurement of CO in a sample of air or flue gas that does not take account of the amount of excess air (oxygen, O_2) diluting the CO concentration. Usually measured in units of parts per million (ppm). See *Air-Free Carbon Monoxide*.

Atmospheric Burner – A burner utilizing *atmospheric combustion*.

Atmospheric Combustion – Combustion which takes place under *atmospheric pressure* at a given altitude.

Atmospheric Pressure – The weight of air and its contained water vapor on the surface of the earth. At sea level this pressure is 14.7 pounds per square inch.

- B -

Backdrafting – Continuous spillage of combustion gases from a vented combustion appliance into the conditioned space.

Backdraft Damper – A damper, installed near a fan, that allows air to flow in only one direction and prevents reverse flow when the fan is off.

Backer Rod – Polyethylene foam rope used as backing for caulking.

Baffle – A plate or strip designed to retard or redirect the flow of flue gases.

Balanced Flue Vent System – Term used for oil-fired systems to indicate a direct-vent appliance with positive pressure in the vent connector through which the gases of combustion pass.

Balloon Framing – A method of construction in which the vertical framing members (studs) are continuous pieces, running the entire height of the wall.

Band Joist – See rim joist.

Barometric Vent Damper – a device installed in the heating unit vent system to control draft. Usually used on oil-fueled units or gas units with power burners.

Batt – A blanket of preformed insulation, generally 14.5" or 22.5" wide, and varying in thickness from 3.5" to 9".

Belly Return – A configuration found in some manufactured homes that uses the belly cavity as the return side of the heating/cooling distribution system.

Blocking – A construction element or material used to prevent the movement of air or insulation into or through building cavities.

Blow-Down – Removing water from a boiler to remove sediment and suspended particulates.

Blower – The “squirrel-cage” fan in a furnace or air handler.

Blower Door – A calibrated device to measure the air tightness of a building by pressurizing or depressurizing the building and measuring the flow through the fan.

Blown Insulation – Loose-fill insulation that is blown into attics and building cavities using an insulation blowing machine.

Boiler – A space heating appliance that heats water with hot combustion gases.

Boot – A duct section that connects between a duct and a register, floor, or wall cavity, or between round and square ducts.

Branch Circuit – An electrical circuit used to power outlets and lights within a home.

Breeching or Breech – See *Vent Connector*.

British Thermal Unit (Btu) – The quantity of heat required at sea level to raise the temperature of one pound of water by one degree Fahrenheit.

Btuh – British thermal units per hour.

Building Cavities – The spaces inside walls, floors, and ceilings or between the interior and exterior sheeting.

Building Science – A complex perspective on buildings, using contemporary technology to analyze and solve problems of design, construction, maintenance, safety, and energy efficiency.

Building Technology Committee (BTC) – A standing committee of the Maine Community Action Housing Council created to advise the Housing Council on technical aspects of issues related to Weatherization (Wx) Programs. The BTC generally consists of Wx field staff from each Maine Community Action Program. BTC meetings serve as a forum for exchange of technical related ideas and experiences from individuals, a forum for review and development of proposed technical documents, and a forum for training of Wx field staff.

Burner – A device that facilitates the burning of a fossil fuel like gas or oil.

Bypass – An air leakage site that allows air to leak out of a building passing around the air barrier and insulation.

- C -

Carbon Dioxide (CO_2) – A heavy, colorless, nonflammable gas formed by the oxidation of carbon, by combustion, and by the respiration of plants and animals.

Carbon Monoxide (CO) – An odorless, colorless, tasteless, and poisonous gas produced by incomplete combustion.

Category I Gas Appliance – An appliance that operates with negative static pressure in the vent and a temperature that is high enough to avoid condensation in vent. *Comment: May be atmospheric or fan-assisted combustion; airtight vent connector is not required.*

Category I Fan-Assisted Gas Appliance – An appliance that operates with negative static pressure in the vent, a temperature that is high enough to avoid condensation in vent, and an integral fan to draw a controlled amount of combustion supply air through the combustion chamber. *Comment: Airtight vent connector is not required; induced combustion fan installed by manufacturer.*

Category II Gas Appliance – An appliance that operates with negative static pressure in the vent and a temperature that is low enough to cause excessive condensation in the vent. *Comment: No or very little equipment in this category.*

Category III Gas Appliance – An appliance that operates with positive static pressure in the vent and a temperature that is high enough to avoid condensation in vent*. Comment: Airtight vent connector; vented through the wall; forced draft.*

Category IV Gas Appliance - An appliance that operates with positive static pressure in the vent and a temperature that is low enough to cause excessive condensation in the vent. *Comment: Airtight vent connector; vented through the wall; forced draft; often referred to as a "90-plus"or "condensing" unit.*

Caulking – A mastic compound for filling joints and cracks.

CAZ – See Combustion Appliance Zone.

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

Central Return – System of ducts or passages for distribution return air, which connect different areas of the house to a central location at the forced air furnace.

Chimney – A building component designed for the sole purpose of assuring combustion by-products are exhausted to the exterior of the building.

Chimney Flue – A passageway in a chimney for exhausting combustion gases to the outdoors.

Circuit Breaker – A device that automatically disconnects an electrical circuit from electricity under a specified or abnormal condition of current flow.

Cleanout Opening – An opening in a chimney (usually at its base) to allow inspection and the removal of ash or debris.

Coefficient of Performance (COP) – A heat pump or air conditioner's output in Watt-hours of heat removed, divided by Watt-hours of electrical input.

Coil – A snakelike piece of copper tubing surrounded by rows of aluminum fins that clamp tightly to the tubing to aid in heat transfer.

Cold Air Return (return side): Ductwork through which house air is drawn for reheating during a furnace's cycle.

Color Rendering Index (CRI) – A measurement of a light source's ability to render colors the same as sunlight does. The CRI has a scale of 0 to 100.

Combustible – Susceptible to combustion; inflammable; any substance that will burn.

Combustion Appliance Zone (CAZ) –The closed space or area that holds one or more combustion appliances.

This may include, but is not limited to, a mechanical room, mechanical closet, or main body of the house.

Combustible Gas Leak Detector – A device for determining the presence and general location of combustible gases in the air.

Combustion – The act or process of burning. Oxygen, fuel, and a spark must be present for combustion to occur.

Combustion Air – Air required to chemically combine with a fuel during combustion to produce heat and flue gases.

Combustion Analyzer – A device used to measure the steady-state efficiency of combustion heating units.

Combustion Appliance – Any appliance in which combustion occurs.

Combustion Chamber – The area inside a heating unit where combustion takes place.

Common Vent – The portion of the vent or chimney through which products of combustion from more than one appliance pass.

Compact Fluorescent Light (CFL) – A small fluorescent light engineered to fit conventional incandescent fixtures.

Concentrically Constructed Direct-Vent – A *direct-vent appliance* that has an exhaust-gas vent and a combustion-supply air vent arranged in a concentric fashion, i.e., one vent is inside the other with a space between the walls of each. *Comment: Manufactured home furnace vents are usually constructed this way; some Category I, direct-vent water heaters are constructed this way.*

Condense – To change from a gaseous or vaporous state to a liquid or solid state by cooling or compression.

Condenser – The coil in an air conditioning system where the refrigerant condenses and releases heat, which is then carried away by air moving across the coil.

Condensate – The liquid formed when a vapor is condensed.

Condensate Receiver – A tank for catching returning condensate water from a steam heating system.

Conditioned Space – A heated or cooled area of a building. Conditioned space includes any area of a dwelling that is determined to be within the thermal/pressure envelope or shell. It includes both habitable space and occupiable space. Basements containing heating systems, water heaters, or washing machines are commonly considered to be part of the conditioned space.

Conductance – The quantity of heat, in Btus, that will flow through one square foot of material in one hour, when there is a one degree Fahrenheit temperature difference between both surfaces. Conductance values are given for a specific thickness of material.

Conduction – The transfer of heat energy through a material (solid, liquid, or gas) by the motion of adjacent atoms and molecules without gross displacement of the particles.

Conductivity – The quantity of heat that will flow through one square foot of homogeneous material, one inch thick, in one hour, when there is a temperature difference of one degree Fahrenheit between its surfaces.

Confined Space – In relation to combustion appliances, a space with a volume of less than 50 cubic feet per 1,000 Btu per hour 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, and not as a result of a grant of funds.

Control Circuit – A device that opens and closes a power circuit or opens and shuts a valve.

Convection – The transmission of heat by the actual movement of a fluid or gas because of differences in temperature, density, etc.

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.

Critical Framing Juncture – An intersection of framing members and envelope components that require special attention during preparation and installation of insulation.

Cross Section – A view of a building component drawn or imagined by cutting through the component.

CFM – Cubic Feet per Minute – A measurement of air movement in cubic feet per minute past a certain point or through a certain structure.

CFM_{50} – The number of cubic feet per minute of air flowing through the fan housing of a blower door when the house pressure is 50 Pa (0.2 inches of water column). This figure is the most common and accurate way of comparing the tightness of buildings that are tested using a blower door.

CFM_{nat} – 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 using the LBL (Lawrence Berkeley Labs) infiltration model.

- D -

Degree-days (DD) – A measure of outdoor temperature produced by summing the temperature differences between the inside (65°F) and the daily average outside temperature for a one-year period.

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

DOE – The United States Department of Energy.

Depressurize – To lower the pressure in an enclosed area with respect to a reference pressure.

Depressurization Tightness Limit (DTL) – A calculation, expressed in units of CFM_{50}, to estimate the building tightness level at which combustion appliances might backdraft when the house is under conditions of worst-case depressurization.

Design Temperature - A high or low temperature used for designing heating and cooling systems when calculating the building load.

Dilution Air – Air that enters through an opening where the chimney joins to an atmospheric-draft combustion appliance.

Dilution Device – A draft diverter, draft hood, or barometric draft control on an atmospheric-draft combustion appliance.

Direct-Vent Appliance – A combustion appliance for which all combustion gases are vented to the outdoors through an exhaust vent pipe and all combustion supply air is vented to the combustion chamber from the outdoors through a separate, dedicated supply-air vent. *Comment: Most direct-vent gas appliances are Categories III and IV, but some are Category I; some direct-vent appliances utilize Concentrically Constructed Direct-Vent.* Contrast direct-vent appliances with Open-Combustion Appliances.

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

DHW – Domestic Hot Water

Dormer – A framed structure projecting above a sloping roof surface, and normally containing a vertical window.

Downdraft – Air flowing down a chimney or vent during the appliance off-cycle.

Draft – A pressure difference that causes combustion gases or air to move through a vent connector, flue, chimney, or combustion chamber. May be *natural draft*, *induced draft*, or *forced draft*. Draft is often measured with a draft gauge (manometer or pressure gauge).

Draft Diverter – See *Draft Hood*.

Draft Fan – A mechanical fan used in a venting system to augment the *natural draft* in gas- and oil-fired appliances. These electrically operated, paddle-fan devices are installed in vent connectors.

Draft Hood – A nonadjustable device built into an appliance or a part of the vent connector that is intended to 1) provide for escape of flue gases if blockage or backdraft occurs, 2) prevent a downdraft of outdoor air from entering the appliance, 3) neutralize the effect of stack action of the chimney, and 4) lower the dew point temperature of the flue gas by the infusion of ambient room air.

Draft Regulator – An adjustable and self-regulating damper attached to a chimney or vent connector for the purpose of controlling draft. A draft regulator can reduce draft; it cannot increase draft.

Drywall – Gypsum interior wallboard used to produce a smooth and level interior wall surface and to resist fire. Also called gypsum wallboard and sheetrock.

Dry Bulb Temperature – Normal ambient air temperature measured by a thermometer.

DTL – See Depressurization Tightness Limit.

Duct Blower – A blower door-like device used for testing duct leakiness and airflow.

Duct Zone – A building space or cavity that contains heating or cooling ducts.

- E -

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

Efficiency – The ratio of output divided by input.

Efficacy – The number of lumens produced by a Watt used for lighting a lamp. Used to describe lighting efficiency.

Electric Service – The electric meter and main switch, usually located outside the building.

Emittance – The rate that a material emits radiant energy from its surface. Also called emissivity.

Encapsulation – Any covering or coating that acts as a barrier between the hazard (e.g., lead-based paint) and the environment, the durability of which relies on adhesion and the integrity of existing bonds between existing layers (e.g., paint) and the substrate.

Enclosure – The use of rigid, durable construction materials that are mechanically fastened to the substrate to act as a barrier between the hazardous material (e.g., lead-based paint) and the environment.

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 Efficiency – Term describing how efficiently a building component uses energy.

EEM – Energy efficiency measure.

Energy Efficiency Ratio (EER) – A measurement of energy efficiency for room air conditioners. The EER is computed by dividing cooling capacity, measured in British Thermal Units per hour (Btuh), by the watts of power. (See also Seasonal Energy Efficiency Rating – SEER)

Envelope – The building shell. The exterior walls, floor, and roof assembly of a building.

Environmentally Sensitive – Highly susceptible to adverse effects of pollutants.

Evaporation – The process of being changed into a vapor or gas at a temperature usually below the boiling point. Evaporation is a cooling process.

Evaporative Cooler – A device for cooling homes which cools the incoming air by the evaporation of water vapor. Works best in dry climates.

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

Exfiltration – Air flowing out of a building from its conditioned space through holes, leaks, or cracks in the shell.

- F -

Fahrenheit – A temperature scale for which water boils at 212° and freezes at 32°.

Fan-Assisted Combustion – A combustion appliance with an integral fan to draw combustion supply air through the combustion chamber. *Comment: Category I fan-assisted gas furnaces utilize this method of combustion air regulation.*

Fan Control – A bimetal thermostat that turns the furnace blower on and off as it senses the presence of heat.

Fan-Off Temperature – In a furnace, the supply air temperature at which the fan control shuts down the distribution blower.

Fan-On Temperature – In a furnace, the supply air temperature at which the fan control activates the distribution blower.

Fenestration – Window and door openings in a building's wall.

Fiberglass – A fibrous material made by spinning molten glass.

Fill Tube – A plastic or metal tube used for its stiffness to blow insulation inside a building cavity and allow the insulation to be delivered at the extreme ends of the cavity.

Fire Stop – Framing member, usually installed horizontally between studs, designed to stop the spread of fire within a wall cavity.

Forced Draft – A vent system for which a fan installed at the combustion appliance moves combustion gases to the outdoors with positive static pressure in the vent pipe. Because of this positive pressure, the vent connector must be air-tight. *Comment: Normally Category III or IV appliances; usually no draft diverter or barometric damper; fan for venting combustion gases at or near appliance; usually vented through the wall; may be condensing.*

Furnace – A space heating appliance that heats air with hot combustion gases.

Furring – Thin wood strips fastened to a wall or ceiling surface as a nailing base for finish materials.

Flame Safety Control – A device that prevents fuel delivery in the event the ignition does not work.

Flammable/Inflammable – Combustible; readily set on fire.

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

Floor Joist – A horizontal framing member that support the floor.

Flue – A vent for combustion gases.

Foam Board – Plastic foam insulation manufactured most commonly in 4' x 8' sheets in thicknesses of ½" to 3".

Foot-Candle – A measure of light striking a surface.

Footing – The part of a foundation system that transfers the weight of the building to the ground.

Friable –Easily broken into small fragments or reduced to powder, e.g., as with asbestos.

Frost Line – The maximum depth of the soil where water will freeze during the coldest weather.

- G -

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.

Gas Oven Bake Burner – Oven burner used for baking located just below the oven compartment floor.

Gas Oven Broiler Burner – Oven burner used for broiling located at the top of the oven compartment. (Examples that are Infiltration ECMs do have an aggregated SIR requirement, insulation items seem to have SIRs in Hancock. This term is not mentioned anywhere in the Standards except here.)

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 Fault Circuit Interrupter (GFI or GFCI) – An electrical connection device that breaks a circuit if a short occurs. These are required for all exterior use of electrical equipment, or when an electrical outlet is located near a water source.

Gypsum Board – A common interior sheeting material for walls and ceilings, made of gypsum rock powder, packed between two sheets of heavy building paper. Also called sheetrock, gyprock, or gypboard.

- H -

Habitable Space – A building space intended for continual human occupancy. Examples include areas used for sleeping, dining, and cooking, but not bathrooms, toilets, hallways, storage areas, closets, or utility rooms. See occupiable space and conditioned space.

Hazardous Condition – A situation that is causing a danger to the client/crew/contractor that exists before, is created by, or is exacerbated by, weatherization. For example, a dwelling could have a moisture problem that is allowing biological hazards (molds, viruses, bacteria, etc.) to flourish. Another example would be fiberglass entering the conditioned space due to improperly fastened or sealed ductwork.

Heat Anticipator – A small electric heater in a thermostat that causes the thermostat to turn off before room temperature reaches the thermostat setting, so that the house does not overheat from heat distributed after the burner shuts off.

Heat Capacity – The quantity of heat required to produce a degree of temperature change.

Heat Exchanger – The device in a heating unit that separates the combustion chamber from the distribution medium and transfers heat from the combustion process to the distribution medium.

Heat Loss – The amount of heat escaping through the building shell during a specified period.

Heat Pump – A type of heating/cooling unit, usually electric, that uses a refrigerant fluid to heat and cool a space.

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

Heating Load – The maximum amount of heat needed by a building during the very coldest weather to maintain the desired inside temperature.

Heating Seasonal Performance Factor (HSPF) – Rating for heat pumps describing how many Btus they transfer per kilowatt-hour of electricity consumed.

HVAC – Heating, Ventilating, Air-Conditioning.

High Limit – A bimetal thermostat that turns the heating element of a furnace off if it senses a dangerously high temperature.

Hip Roof – A roof with two or more contiguous slopes, joined along a sloping "hip."

Home Energy Index – The number of Btus of energy used by a home, divided by its area of conditioned square feet and by the number of heating degree days during one year.

HVI – Home Ventilating Institute.

Housing Council – An affiliate group of the Maine Community Action Association whose primary focus is to oversee management and completion of Housing programs, policies, and issues, including weatherization, throughout Maine. The membership of the group is representative of all community action programs in Maine through their Housing Services Director or designee.

House Pressure – The difference in pressure between the inside and outside of the house.

HUD – United States Department of Housing and Urban Development.

Humidistat – An automatic control that switches a fan, humidifier, or dehumidifier on and off, based on the relative humidity at the control.

Humidity Ratio – The absolute amount of air’s humidity measured in pounds of water vapor per pound of dry air.

Hydronic System – A heating system using hot water or steam as the heat transfer medium. Commonly called a hot-water heating system.

- I -

IAQ – Indoor Air Quality.

IC Electrical Fixture – A light or fan/light combination electrical fixture that is rated for direct contact with thermal insulation.

Illumination – The light level measured on a horizontal plane in foot-candles.

Incandescent light – The common light bulb found in residential lamps and light fixtures and sold in stores everywhere and is known for its inefficiency.

Inaccessible Cavity – An area that is too confined to enter and/or maneuver in by an average installer/mechanic.

Inches of Water Column (IWC) – A non-metric unit of pressure difference. One IWC is equal to about 0.004 Pascals.

Induced Combustion – See *Fan-Assisted Combustion*.

Induced Draft – A vent system for which a fan – installed at or very near the termination point of the vent pipe – moves the combustion gases to the outdoors with negative static pressure in the vent pipe. *Comment: Normally Category I appliances; fan for venting combustion gases at point of exit to outdoors); vented through the wall.*

Infiltration – The uncontrolled movement of non-conditioned air into a conditioned air space.

Infrared – Pertaining to heat rays emitted by the sun or warm objects on earth.

Input Rating – The designed capacity of an appliance, usually specified in Btus or units of energy.

Isolated Outdoor Air Supply - Term used with oil-fired systems to indicate a vent pipe through which outdoor combustion supply is ducted to the oil burner. *Comment: Often added on-site, these non-airtight outdoor air supply vents are sometimes installed with a vacuum relief damper that allows all the combustion supply air to be taken from the CAZ if the outdoor air inlet becomes blocked.*

Insulating Glass – Two or more glass panes spaced apart and sealed in a factory, and having a higher R-value than a single pane of glass.

Insulation – A material used to retard heat transfer.

Intermittent Ignition Device (IID) – A device that lights the pilot light on a gas appliance when the control system calls for heat, thus saving the energy wasted by a standing pilot.

Internal Gains – The heat generated by bathing, cooking, and operating appliances. At times, internal heat gains must be removed during the summer to promote comfort and they can reduce the heating demand in the winter.

Interstitial Space – Space between framing and other building components.

- J -

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

Joule – A unit of energy. One thousand joules equals 1 Btu.

- K -

Kilowatt – One thousand watts. A unit of measurement of the amount of electricity needed to operate given equipment.

Kilowatt-Hour – The most commonly used unit for measuring the amount of electricity consumed over time; one kilowatt of electricity supplied for one hour.

Kinetic Energy – Consisting of, or depending on, motion; distinguished from potential energy.

- L -

Lamp – A light bulb.

Latent Heat – The amount of heat energy required to change the state of a substance from a solid to a liquid or from a liquid to a gas, without changing the temperature of the substance.

Lath – A support for plaster, consisting of thin strips of wood, metal mesh, or gypsum board.

Lead-Safe Work Practices – Work practices required by the DOE for most pre-1978 homes.

Light Quality – The relative presence or absence of glare and brightness contrast. Good light quality has no glare and low brightness contrast.

Limited Energy Auditor Technician's License – License granted by the Maine Fuel Board, allowing Maine-certified energy auditors to perform specific tests on oil- and gas-fired combustion appliances. No adjustments may be made to appliances during this testing. A separate license must be obtained from each board in order to test combustion appliances that are regulated by that board.

Living-Space-Return System – In a manufactured home, a forced warm air circulation system where air returns to the air handler through the living space, rather than through ductwork or through the manufactured home belly.

Local Ventilation – A term used in ASHRAE 62.2 that refers to ventilation serving bathrooms and kitchens, as contrasted with whole-building ventilation. Local ventilation is intended to exhaust odors and moisture at their source and thereby enhance the indoor air quality.

Low-Water Cutoff – A float-operated control for turning the burner off in a steam or hot water boiler if low on water.

Lumen – A unit of light output from a lamp.

Low-E – Short for "low emissivity", which refers to having a metallic glass coating to resist the flow of radiant heat.

- M -

MaineHousing – Maine State Housing Authority.

Main Panel Box – The electric service box containing a main switch, and the fuses or circuit breakers located inside the home.

Make-Up Air – Air supplied to a space to replace exhausted air.

Manifold – A tube with one inlet and multiple outlets, or multiple inlets and one outlet.

Manometer – A differential gauge used for measuring pressure.

Manufactured Home – A mobile home or a "double-wide" structure.

Masonry – Stone, brick, or concrete block construction.

Mastic – A thick, creamy substance used to seal seams and cracks in building materials, and especially useful on ductwork.

Mechanical Draft – A combustion appliance with induced draft of forced draft.

MHEA – Manufactured Housing Energy Audit, developed by the Department of Energy for weatherization assistance programs. Used to audit manufactured homes.

Mitigate – To make less severe.

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

- N -

Natural Draft – A vent system that relies on natural draft (hot, buoyant air) to move combustion gases to the outdoors. *Comment: Category I appliances; atmospheric, fan-assisted, or power burner type combustion; sometimes direct-vent; might be through-the-wall vented.*

Natural Ventilation – Ventilation using only natural air movement, without fans or other mechanical devices.

NBS – The National Bureau of Standards, renamed by the Department of Commerce as the National Institute of Standards and Technology (NIST).

NEMA – National Electrical Manufacturers' Association

NEAT – National Energy AudiT, developed by the Department of Energy for weatherization assistance programs. Used to audit single-family and low-rise multi-family buildings.

NFPA – National Fire Protection Association.

Net Free Vent Area (NFVA) – The area of a vent, adjusted for the restrictions caused by insect screen, louvers, and weather coverings. The free area is always less than the actual area.

Nozzle – An orifice designed to change a liquid like oil into a mist to improve the combustion process.

- O -

O_2 – Oxygen.

Occupants – People of any age living in a dwelling. Animals are not defined as occupants.

Occupiable Space – An enclosed space inside the pressure boundary of a room or house, and intended for human activities including, but not limited to, all habitable spaces, bathrooms, closets, halls, storage and utility areas, and laundry areas. See habitable space and conditioned space.

Ohm – A unit of measure of electrical resistance. One volt can produce a current of one ampere through a resistance on one ohm.

Open-Combustion Appliance – A combustion appliance that takes its combustion supply air from the surrounding room, usually Category I or Category I fan-assisted, natural draft. Contrast this with direct-vent or sealed combustion appliance witch take combustion supply air directly from the outdoors.

Orifice – A hole in a nozzle where gas exits to be mixed with air in a burner before combustion in a heating device. The size of the orifice will help determine the flow rate.

OSHA – Occupational Health and Safety Administration, a division of the U.S. Department of Labor whose mission is to assure safe and healthful working conditions for working men and women.

OSHA Confined Spaces Standards - In relation to weatherization activities, a protocol to be followed when activities are prescribed in what is defined by OSHA as a confined space.

Output Capacity – The useful heat or work that a device produces after accounting for the energy wasted in the energy conversion process.

Oxygen Depletion Sensor (ODS) – A safety device for unvented (vent-free) combustion heaters that shuts off gas when oxygen is depleted.

- P -

Parts per Million (ppm) – The unit commonly used to represent the degree of pollutant concentration, where the concentrations are small.

Pascal (Pa) – A metric unit of measurement of air pressure. 250 Pa = 1 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.

Perimeter Pull – A technique used in attics previously insulated with batt insulation. The batts are cut back two feet from the eaves and the area is insulated with blown insulation to ensure coverage over the outer wall top plate, and to prevent wind washing of the insulation under the existing batts.

Perlite – A heat-expanded mineral used for insulation.

Perm – A measurement of how much water vapor a material will let pass through it, per unit of time, under a specified pressure difference.

Pitot Tube – A device for measuring fluid velocity. An instrument placed in a moving fluid and used along with a manometer to measure fluid velocity.

Plaster – A mixture of sand, lime, and Portland cement spread over wood or metal lathe to form the interior surfaces of walls and ceilings.

Plate – A framing member installed horizontally to which the vertical studs in a wall frame are attached.

Plenum – The section of ductwork that connects the air handler to the main supply duct.

Plywood – Laminated wood sheeting with layers cross-grained to each other.

Polyethylene – A plastic made by the polymerization of ethylene, used in making translucent, lightweight, and tough plastics, films, insulations, vapor retarders, air barriers, etc.

Polyisocyanurate – Plastic foam insulation sold in sheets, similar in composition to polyurethane.

Polystyrene Insulation – rigid plastic foam insulation, usually white, blue, pink, or green in color.

Polyurethane – versatile plastic foam insulation, usually yellow in color.

Potential Energy – Energy in a stored or packaged form.

Pressure – A force that encourages movement by virtue of a difference in some condition between two areas. High pressure moves to low pressure.

Power Burner – A burner for which air is supplied at a pressure greater than atmospheric pressure. Most oil-fired burners are power burners. Gas burners used to replace oil burners are usually power burners.

Power Draft – See *Mechanical Draft*.

Pressure Diagnostics – The practice of measuring pressures and flows in buildings to control air leakage, and to ensure adequate heating, cooling, and ventilation.

Pressure Pan – A device used to block a duct register while measuring the pressure behind it.

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

Pressuretrol – A control that turns a steam boiler's burner on and off as steam pressure changes.

Primary Window – The main window installed on the outside wall. Not to be confused with a storm window.

- R -

R-value – A measurement of thermal resistance.

Radiant Barrier – A foil sheet or coating designed to reflect radiant heat flow. Radiant barriers are not mass insulating materials.

Radiant Temperature – The average temperature of objects in a home, including walls, ceiling, floor, furniture, and other objects.

Radiation – Heat energy that is transferred by electromagnetic energy or infrared light, from one object to another. Radiant heat can travel through a vacuum and other transparent materials.

Radon – A radioactive gas that decomposes into radioactive particles.

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

Reflectance – The ratio of lamination or radiant heat reflected from a given surface to the total light falling on it. Also called reflectivity.

Refrigerant – Any of various liquids that vaporize at a low temperature, used in mechanical refrigeration.

Register – A grille covering a duct supply outlet used to diffuse the airflow and sometimes control the flow.

Relative Humidity – The percent of moisture present in the air compared to the maximum amount possible at that given temperature. Air that is saturated has 100% relative humidity.

Relay – An automatic, electrically operated switch.

Reset Controller – A device that adjusts fluid temperature or pressure in a central heating system according to outdoor air temperature.

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, the action of improving the thermal performance or structural condition of a building.

Return Air – Air circulating back to the furnace or central air conditioning unit from the house, to be heated or cooled and supplied back to the living area.

Rim Joist – The outermost joist around the perimeter of the floor framing.

Rocking on the High Limit – Refers to the gas burner being shut down by the high limit switch on a furnace, instead of being properly activated by the fan-on/fan-off control.

Room Air Conditioner – An air conditioning unit installed through a wall or window, which cools the room by removing heat and releasing it outdoors.

- S -

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

Savings-to-Investment Ratio (SIR) – For an energy saving measure, the ratio of the savings divided by the investment (cost), including the discounted investment value and escalation of fuel costs. See SIR below.

SDS –Safety Data Sheet. (Formerly MSDS-Material Safety Data Sheet)

Sealed-Combustion Appliance – An appliance that draws combustion air from outdoors and has a sealed exhaust system. Also called a direct-vent appliance.

Seasonal Energy Efficiency Ratio (SEER) – A measurement of energy efficiency for central air conditioners. The SEER is computed by dividing cooling capacity, measured in Btuh, by the Watts (see also Energy Efficiency Rating).

Sensible Heat – The heat required to change the temperature of a material without changing its form.

Shall – For the purposes of this Standard, the word "shall" means the action is required. If, for any reason, a required act or task cannot be done, the reasons must be documented in the client file.

Sheathing – Structural sheeting, attached on top of the framing, underneath the siding and roofing of a building. Any building material used for covering a building surface.

Sheetrock – See drywall.

Shell – The building’s exterior envelope – the walls, floor, and roof of a building.

Shingle – A roofing component installed in overlapping rows.

Should – For the purposes of this Standard, the word "should" means the action is strongly recommended, but not required.

Short Circuit – A dangerous malfunction in an electrical circuit, where electricity is flowing through conductors and into the ground without going through an electric load, such as a light or motor.

Sill – The bottom of a window or doorframe.

Sill Box – The area bounded by the rim joist, floor joists, sill plate, and floor.

SIR – Savings-to-Investment Ratio. The SIR value of an energy-saving measure should be at least one for it to be installed. The equation used for SIR is below. The Life of a measure is discounted with factors published by the Department of Energy every April.

SIR = (Annual Savings from Measure/Cost of Measure) X Discounted Live of Measure

Site-Built Home – Includes a house built on the site from building supplies, or prefabricated homes assembled on the site from pieces shipped to the site on flatbed trucks. Does not include manufactured homes and double-wides which have a chassis and wheels integrated into their construction and are already constructed before delivery to the site. .

Sling Psychrometer – A device holding two thermometers, one wet bulb and one dry bulb, which is slung through the air to determine relative humidity.

Slope – The roof section of an attic with the roof and ceiling surfaces attached to the rafters.

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

Solar Gain – Heat from the sun that is absorbed by a building.

Solenoid – A magnetic device that moves a switch or valve stem.

Space Heating – Heating the habitable spaces of the home with a room heater or central heating system.

Spillage – Combustion gases emerging from an appliance or venting system into the CAZ during burner operation.

Stack Effect – The tendency for warm buoyant air to rise and leak out of the top of the house and be replaced by colder outside air entering from the bottom of the house.

Steady-State Efficiency (SSE) – The efficiency of a heating appliance, after an initial start-up period and while the burner is operating, that states how much heat crosses the heat exchanger. The steady-state efficiency is measured by a combustion analyzer.

Steam Trap – An automatic valve that closes to trap steam in a radiator until it condenses.

Steam Vent – A bimetal-operated vent that allows air to leave steam pipes and radiators, but closes when exposed to steam.

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

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

Supply Air – Air that has been heated or cooled and is then moved through the ducts and out the supply registers of a home.

Suspended Ceiling – Modular ceiling panels supported by a hanging frame.

- T -

Temperature Rise – In a furnace, the number of degrees of temperature the distribution air is increased as it passes over the heat exchanger. Temperature rise equals heated air temperature minus air return temperature.

Therm – A unit of energy equivalent to 100,000 Btus or 29.3 kilowatt-hours.

Thermal Break – A piece of relatively low-conducting material between two high conducting materials, installed to reduce heat flow through the assembly.

Thermal Bridging – Rapid heat conduction resulting from direct contact between thermally conductive materials like metal and glass.

Thermal Boundary – A ceiling/roof, wall, floor, window, or door that separates the habitable, occupiable, and conditioned spaces from the outdoor weather. The thermal boundary should be air sealed and/or insulated if it is cost effective to do so. Exterior doors are always examples of thermal boundaries. An attic floor is most often an example of a thermal boundary.

Thermal Bypass – An indirect penetration that tends to reduce the effectiveness of insulation by allowing conditioned air to move out of a structure, or allowing unconditioned air to move in.

Thermal Conductance – A material's ability to transmit heat; the inverse of the R-value (see U-factor).

Thermal Resistance – R-value; a measurement expressing the ability to retard heat flow.

Thermocouple – A bimetal-junction electric generator used to control the safety valve of an automatic gas valve.

Thermostat – A device used to control a heating or cooling system to maintain a set temperature.

Through-the-Wall Vented – Combustion appliances that are vented through a wall rather than into a vertical-rise chimney or vent. Such appliances are usually Category III or IV, but might also be Category I (for example, a direct-vent Category I water heater).

Transformer – A double coil of wire that reduces or increases voltage from a primary circuit to a secondary circuit.

Truss – A braced framework usually in the shape of a triangle to form and support a roof.

- U -

U-factor – The total heat transmission in Btus per square feet per hour with a 1°F temperature difference between the inside and the outside; the thermal conductance of a material.

Ultraviolet Radiation – Light radiation having wavelengths beyond the violet end of the visible spectrum; high frequency light waves.

Unconditioned Space – An area within the building envelope that is not heated or cooled, but tends to be the same temperature as outside.

Underlayment – Sheeting installed to provide a smooth, sound base for a finish material.

UL – Underwriter's Laboratory

- V -

Vapor Barrier – A material with a vapor permeance of 1 or less.

Vapor Diffusion – The flow of water vapor through a solid material.

Vapor Retarder – A material with a vapor permeance between 1 and 10.

Vaporize – To change from a liquid to a gas.

Vent Connector – A pipe that connects the combustion appliance to a vent, chimney, or runs directly to the outdoors.

Vent Damper – An automatic damper powered by heat or electricity that closes the chimney while a heating device is off.

Ventilation – The movement of air through an area to remove moisture, air pollution, or unwanted heat.

Venting – The removal of combustion gases by a chimney.

Venting System – A continuous passageway from a combustion appliance to the outdoors through which combustion gases can safety pass.

Vermiculite – A heat-expanded mineral used for insulation.

Volt – A unit of electromotive force. It is the amount of force required to drive a steady current of one ampere through a resistance of one ohm. Electrical systems of most homes in the United States have 120-volt systems.

- W -

Watt (W) – A unit measure of electric power at a point in time, as capacity or demand. One Watt of power maintained over time is equal to one joule per second.

Watt-hour – One Watt of power extended for one hour. One thousandth of a kilowatt-hour.

Weatherization – The process of reducing energy consumption and increasing comfort in buildings by improving the energy efficiency of the building and maintaining health and safety.

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

WAP – Weatherization Assistance Program.

Weep Holes – Drilled holes that allow water to drain out of an area of a building component where it may accumulate.

Wet Bulb Temperature – The temperature of a dampened thermometer of a sling psychrometer used to determine relative humidity.

Whole-Building Ventilation -- A term used in ASHRAE 62.2 that refers to ventilation serving the entire living area, as contrasted with “local ventilation” which serves only bathrooms and kitchens. Whole-building ventilation is intended to provide fresh outdoor dilution air and thereby enhance the indoor air quality.

Window Films – Plastic films, coated with a metalized reflective surface that are adhered to window glass to reflect infrared rays from the sun.

Window Frame – The sides, top, and sill of the window, which form a box around window sashes and other components.

Worst-Case Depressurization – A condition created when 1) all exhaust appliances (bathroom exhaust, kitchen exhaust, vented dryers, etc.) are operating, 2) the interior doors of a house are in a position that causes the greatest negative pressure in the Combustion Appliance Zone, and 3) the furnace air handler is operating (if such operation causes increased negative pressure in the Combustion Appliance Zone).

Worst-Case Depressurization Test – A test that creates Worst-Case Depressurization in a Combustion Appliance Zone (CAZ). This test is used to determine if combustion appliances will vent properly under these worst-case conditions.

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