Maine Weatherization Standards

Low-Income Weatherization Assistance Program

April 2011

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Weatherization Works

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MaineHousing
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The Maine Weatherization Standards were selected as best practices for the northern United States and adopted for the Maine weatherization program.

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Introduction

The Maine Weatherization Standards provide guidelines to local administering agencies and contractors regarding the proper delivery of weatherization services for residential buildings. The purpose of the Standards is to ensure that high quality service is given at a reasonable cost and is delivered uniformly throughout Maine. The success of this program depends upon agencies and contractors having a full understanding of these weatherization standards.

The objective of this document is two-fold. First, it serves to define the appropriate application of weatherization measures for each residence serviced. The Standards delineate material specifications as well as the steps that should be followed to complete each measure. Alternative methods will be allowed, but whatever method is used must meet or exceed the standard described in the relevant section of this document.

Second, these Weatherization Standards set guides for the expectation of quality of the installed product. Procedures are included for evaluating the quality of each installed conservation measure and the overall quality of the completed job.

Additionally, it is anticipated that these Standards will help ensure that weatherization program funds are used in the most cost-effective manner possible.

This document is intended to represent the best thinking at the time of writing. It is also intended to be a dynamic document, changing as necessary to reflect advances in best practices for weatherization and the health and safety of clients and weatherization personnel.

All testing procedures, inspections, and safety checks performed by agency personnel and contractors will be done with the attempt to follow the tone and spirit of these Standards. No testing is to be performed by persons not holding appropriate licenses or certifications for doing so. It is understood by the MaineHousing, that audit results constitute an opinion of observable conditions at the time of the audit/inspection. It is also understood that sometimes other deficiencies may exist beyond those observed.

The Weatherization Program has changed substantially, both technically and administratively, since its inception over three decades ago. The weatherization

process continues to evolve in response to changes in funding, weatherization technology, program rules, and administrative personnel. The Maine Weatherization Standards will be used to implement and document these changes as they occur. Refer to Section 1.4 on page 4 for details.

From time to time, these Standards may be amended and/or revised by the MaineHousing Energy & Housing Services Division, to reflect changes in state or federal regulations, advances in technology, and/or innovative approaches to weatherization. These Standards are organized to easily accommodate changes.

1 Administrative, Scope, and General Requirements

1.1 Effective Date

1. All weatherization measures performed or completed on or after the date specified in the agency agreement shall comply with these Standards.
2. All dwelling units audited after April 1, 2011 shall comply with these standards.

1.2 Scope

1. The goal for the MaineHousing Energy & Housing Services Division (EHS) Weatherization Assistance Program (WAP) is:

"To provide weatherization assistance which increases the energy efficiency of dwellings owned or occupied by low-income persons, reduce their total residential energy expenditures, and improve their health and safety, especially low-income persons who are particularly vulnerable such as the elderly, the handicapped, and children."

2. The Maine Weatherization Standards shall be known as the Field Standards and may be referred to throughout this document as "the Standards," "WAP Standards", or "Field Standards."
3. The Standards shall apply to all local administering agencies providing Weatherization Assistance Program (WAP) services.
4. The Standards provide guidelines for the installation of energy conservation measures and repairs. Materials and measures that are preferred or not allowed will be specifically designated.
5. Items designated as “preferred approaches” are not required, nor are they mandatory. Agencies will be in compliance with the Standards if they choose not to implement items listed as “preferred”, as long as the alternate method selected provides an equivalent or better result as measured by effectiveness and the savings-to-investment ratio.

However, the preferred approaches are provided as allowable options that will help to maximize the effectiveness of WAP services, protect the health and safety of clients and crews, and contribute to increased energy savings.

6. These Standards are not intended to abridge safety, health, environmental, or local codes or other ordinances. Such requirements, if more stringent than these, shall apply; if these Standards are more stringent, the Standards shall apply.
7. All questions concerning the content or implementation of the Standards should be directed to MaineHousing's Energy & Housing Services Division (EHS).

1.3 Enforcement

1. Continued agency inability and/or refusal to comply with these Standards are grounds for MaineHousing to suspend, terminate, or otherwise apply special condition(s) to the agency's agreement to provide weatherization services.

1.4 Amendments to Program Field Standards

1. From time to time, these Standards may be amended and/or revised by the MaineHousing's Energy & Housing Services Division (EHS), to reflect changes in state or federal regulations, advances in technology, and/or innovative approaches to weatherization. The EHS encourages agencies and contractors to submit suggested changes to these Standards that will result in the delivery of services in a more cost-effective manner while continuing to provide high quality work.
2. Amendments to these Standards will not become effective until thirty (30) calendar days from the date of EHS approval and agency notification, except under the following conditions where amendments or revisions will become effective immediately:
   a. Changes in State or federal law or regulations mandate immediate implementation; or
   b. The EHS determines that an emergency situation exists, such as a potential threat to life, limb, or personal property, and the proposed amendment and/or revision is necessary for the protection of the health and welfare of Maine citizens.
3. Any agency or contractor personnel may submit comments and suggested changes or revisions to these Standards to EHS at any

time. Suggested changes to the Standards must be accompanied by supporting documentation.

4. Outside of federal mandates, the process for implementation of change will be either by recommendation of MaineHousing's technical staff to MaineHousing's Director of the Energy & Housing Services Division (EHS), or by:
   a. Introduction by the Building Technology Committee (BTC), followed by recommendation to the Housing Council (HC); and
   b. Acceptance of BTC recommendation by the HC and a recommendation to MaineHousing, Director of the EHS; followed by
   c. Adoption by MaineHousing and circulation to agency and contractor weatherization providers; and
   d. Issuance of dated replacement pages reflecting changes as they are adopted.
5. All changes, however initiated, will be reflected on an official change notice indicating an effective date and be distributed to the Housing Directors. MaineHousing will seek feedback to these changes as appropriate.

1.5 Applicable Codes and Standards

All repair and installation work shall conform to the 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; and ASHRAE 62.2-2010 Ventilation and Indoor Air Quality in Low-Rise Residential Buildings.

1.6 Quality of Work

1. At no time during the job shall the contractor store any materials and tools in living areas of the dwelling. Tools and materials shall be placed in proper storage chests or job trailers at the end of each workday. With the homeowner's consent, the contractor may store items in non-living spaces on the property.
2. Care shall be taken to assure that the new trim blends into the existing character of the home and is of equal or better quality.
3. Any exterior wood trim installed on the home shall have all four sides primed. Any interior materials installed on the home shall be of a

material to match the existing trim located in the home. At no time shall interior trim be installed in a manner that is less than square stock select pine. All trim installed shall be free of loose knots and all sides should be finished.

4. MaineHousing strongly encourages the contractor to utilize pre-primed manufactured trim, such as Windsor One or Prime-lock materials. These materials are manufactured in 16-foot lengths. The use of these materials eliminates the need to prime materials in place and provides the homeowner with a more finished product.
5. All materials being installed by the contractor shall be installed to match the existing trim or finish material that is adjacent to the new installed trim.
6. Building permits, electrical permits, plumbing permits and other permits required by local or State authorities shall be obtained by the contractor and the costs of such permits shall be the responsibility of the contractor. Permits must be obtained prior to commencement of work and copies of permits must be provided to the owner and the lending agency. Failure to obtain required permits will result in nonpayment of work until the necessary permits are obtained.
7. Workmanship and materials not covered by manufacturers' warranties shall be warranted by the contractors for a period of at least one year from date of final payment to the contractor. All manufacturers' warranties shall be delivered by the contractor to the CAA for inclusion in the final job packet.
8. Installed measures must use materials that meet or exceed the standards listed in Appendix A of 10 CFR Part 440.

2 Weatherization Personnel

2.1 Personnel Knowledge, Skills, and Abilities (KSAs)

The competencies and skills of Maine Weatherization Program personnel are important to define and achieve. Because of the length of the KSAs section, it is located in Chapter 15 starting on page 168. The weatherization personnel knowledge, skills, and abilities listed in this section ensure that individuals working with the Maine weatherization program will remain at the forefront of this trend and bring the professionalism to their work that clients deserve.

2.2 Limited Energy Auditor Technicians Licenses

Energy auditors working with the MaineHousing low-income weatherization program must hold a valid Limited Energy Auditor Technicians license for both oil-fired and gas-fired combustion appliances. It shall be the energy auditor's responsibility 1) to ensure that she/he has the proper training for each of these licenses and 2) to keep the licenses up to date.

Energy auditors shall comply with the rules of the Maine Fuel Board. These rules are reproduced below:[1]

2.2.1 Application and Licensure

a. In order to qualify for a limited energy auditor technician license, an applicant must provide evidence of satisfactory completion of the Certified Building Analyst 1 certification test and field examination offered by the Building Performance Institute, the equivalent Maine residential energy auditor certification program, or an equivalent training program acceptable to the Board[2].
b. Each applicant for a limited energy auditor technician license shall apply by completing and submitting forms provided by the Board, together with evidence of satisfactory completion of the Certified Building Analyst 1 certification test and field examination offered by the Building Performance Institute, the equivalent Maine residential energy auditor certification program, or an equivalent training program acceptable to the Board.

[1] These rules are current as of March 2011.
[2] The Oil and Solid Fuel Board and/or the Propane and Natural Gas Board.

c. Applicants must complete and submit forms to the Oil and Solid Fuel Board in order to test oil-fired equipment and to the Propane and Natural Gas Board in order to test gas-fired equipment.

2.2.2 Scope of Practice

a. A limited energy auditor technician is limited to performing combustion safety and efficiency testing on gas-fired space heating or water heating equipment with the appropriate license from the Propane and Natural Gas Board and limited to performing combustion safety and efficiency testing on oil-fired space heating or water heating equipment with the appropriate license from the Oil and Solid Fuel Board. *Limited energy auditor technicians may not make any adjustments to any space heating or water heating equipment.*
b. Prior to performing a combustion safety and efficiency test, a limited energy auditor technician shall obtain the manufacturer's installation and operating instructions for the specific equipment to be tested.
c. A limited energy auditor technician shall observe all provisions of the manufacturer's installation and operating instructions when performing a combustion safety and efficiency test, including but not limited to any restrictions or limitations relating to equipment access and exhaust pipe penetration.
d. The limited energy auditor technician shall provide a copy of the test results to the homeowner. If the combustion efficiency test results do not fall within the guidelines contained in the manufacturer's installation and operating instructions, the limited energy auditor technician shall notify the homeowner and occupant in writing.

2.2.3 Term of License

a. A valid limited energy auditor technician license must be maintained in accordance with the Fuel Board's requirements.

2.3 Weatherization Personnel Certification

To work in the Maine Weatherization Program, an energy auditor must be credentialed through an Energy Auditor certification program recognized by MaineHousing. The current recognized certifications include the Maine Residential Energy Auditor and Building Performance Institute's (BPI) Building

Analyst Professional; however, as DOE finalizes their required Knowledge, Skills, and Abilities (KSA), noted in Chapter 15 of these Standards, Maine will recognize any certification received from the successful completion of a DOE approved curriculum.

3 Energy Audit Requirements

3.1 General Energy Audit Requirements

1. The following documents are required in each job file after job completion:
    a. Property Owner Consent Form must be explained to the property owner and client by the energy auditor and signed by the property owner, client and the auditor.
    b. MaineHousing Energy Audit Field Form must be filled out by the energy auditor.
    c. Work Order generated by the MaineHousing approved software must be completed by the energy auditor.
    d. Maine State Historic Preservation Office (SHPO) Form – Section 106 Checklist – must be filled out by the energy auditor.
    e. MaineHousing Greenhouse Gas Emissions Release Form must be signed by the property owner and/or client.
    f. MaineHousing Lead Form must be filled out by the auditor.
    g. Client Education Check List must be signed by the client and auditor.
    h. Statement of Completion Form must be filled out by the auditor and signed by the property owner, client and auditor.
    i. Proof of ownership.
    j. Other forms as required by MaineHousing
2. The Maine Energy Audit Field Form must be completed by the auditor. See Section 3.2, below.
3. The approved energy audit must be completed by the auditor. See Section 3.3 below.

4. A work order must be completed for the job by the auditor. See Section 3.4 below.
5. The agency's Statement of Completion form must be filled in by the auditor, explained to the client by the auditor, and signed by the client and the auditor.

3.2 Maine Energy Audit Field Form

1. An energy audit of each dwelling must be conducted and documented in the client file.
   a. *Exception:* In the case of multifamily buildings –25 units or greater, 3 stories or greater, units with large central heating systems, or units with large common areas – agencies and contractors must work in consultation with MaineHousing.
2. All required sections on the form must be filled in with the correct information for the job. If information cannot be provided, a written reason must be documented in the client file.
3. Using the form, the energy auditor must include:
   a. The client and job identification;
   b. An energy index calculation in units of Btu/ft^2, heating degree day;
   c. An indoor air quality and moisture assessment documented with comments;
   d. Results of pre- and post-weatherization blower door tests;
   e. Calculation demonstrating compliance with ASHRAE 62.2-2010;
   f. An inventory of combustion appliances;
   g. Record of the pre- and post-weatherization combustion safety testing, including a worst-case depressurization, spillage, draft, CO in vent connector, and combustion efficiency testing in compliance with the Limited Energy Auditors License requirements;
   h. An insulation assessment, including existing and recommended insulation levels for all appropriate thermal boundaries;
   i. The results of zone pressure diagnostics, if appropriate;
   j. A ductwork assessment, if appropriate;
   k. Results of pressure pan testing for manufactured homes.
   l. Pertinent refrigerator information for referral to the ARP program;
   m. A general baseload audit that includes an inventory of electrical appliances for the purpose of assessing their usage; and

n. An inventory of incandescent lights and the cost effectiveness of replacing them with compact fluorescent lamps (CFLs).

4. The prescriptive installation of weatherization materials or repairs without appropriate justification from an approved energy audit is not allowed.
5. The thermal and pressure boundaries of each dwelling must be determined during the field audit. This includes the identification of each part of the thermal shell or envelope.
6. All building cavities that define the thermal and pressure boundaries between the conditioned and unconditioned spaces must be inspected and measured for existing insulation R-values, air leakage, structural integrity, and the need for repairs.
7. The energy audit must identify the most appropriate methods for:
   a. Reducing air leakage and convective bypasses;
   b. Increasing the insulating value of thermal boundary surfaces, when appropriate; and
   c. Health and safety.

3.3 Approved Energy Audit Software

1. If repairs must be done in order to protect the integrity of an eligible measure, the repair costs must be included with the overall job savings-to-investment ratio (SIR) calculation.
2. Values and methods used for the ~~a~~approved energy audit will be periodically updated by either the agency or statewide committees as follows:
   a. Labor and material cost estimations used for the approved audit must be updated at least once each year, and procedures used to derive these estimated costs must be documented by the agency.
      i. Labor costs shall include fringe benefits as defined by the agency's accounting system.
      ii. Insulation cost estimates must be based on the manufacturer’s recommended installation specifications.
   b. The Building Technology Committee (BTC), made up of technical staff from MaineHousing and the Community Action Agencies, will recommend to the appropriate organization (either the Housing Council or MaineHousing) changes each year to the approved energy audit software.

3.4 Work Order Requirements

1. Each file must have an accurate work order generated by the approved MaineHousing software.
    a. Exception: In the case of multi-family buildings that are 25 units or greater, 3 stories or greater, units with large central heating systems, or units with large common areas, agencies and contractors must work in consultation with MaineHousing.
1. An acceptable work order is one for which all installed energy saving measures have a Savings-to-Investment Ratio (SIR) of 1.00 or greater. The work order generated using the MaineHousing approved software shall include:
    a. Individual conductive and mechanical measures for which SIR values are less than 1.00 are ineligible.
    b. The aggregate of the air infiltration measures shall have an SIR of 1.00 or greater.
    c. All energy-saving measures must be considered and ranked in order of descending SIR. Installing a measure with a lower SIR without installing others with greater SIR is forbidden; in other words, measures may not be skipped.
2. If, because of a valid reason, all measures having an SIR of one or greater are not installed, a written explanation must be included in the client file. The work order must include any appropriate special instructions for necessary inspections or unusual installations.

3.5 Equipment Maintenance

1. All test equipment used for diagnostics, evaluation, and installation of measures shall be maintained according to the manufacturer's recommendations. The agency shall maintain an accurate and current maintenance service log on such equipment. The agency shall be required to maintain all documentation and may be audited at any time by MaineHousing or others. This includes:
    a. Calibration of electronic equipment, including, but not limited to:
        i. Instruments for measuring carbon monoxide.
        ii. Instruments for measuring combustion efficiency.
        iii. Equipment for measuring electrical consumption.
        iv. Digital manometers.
    b. Recommended maintenance of mechanical equipment and electric motors, including, but not limited to:

i. Blower door fans.
ii. Analog manometers.
iii. Insulation installation equipment, including their motors, hoses, seals, and filters.

2. Agencies should develop and adhere to an equipment maintenance and calibration schedule for equipment used by energy auditors.

4 Health and Safety Requirements

4.1 Introduction

The primary goal for Maine's Weatherization Program is to implement cost-effective weatherization procedures to conserve energy and to assess and correct related health and safety hazards for the wellbeing of clients, their dwellings, and weatherization personnel.

The weatherization assistance provided by local agencies and contractors has the potential to affect the operation of, and the interaction among, the various "systems" within clients' homes. It is therefore important that agency and contractor staff remain aware of the potential hazards associated with the weatherization process and not compromise the integrity of client safety, weatherization personnel or the building when installing weatherization measures.

While the primary purpose of the Maine Weatherization Assistance Program is to reduce the energy use in low-income dwellings, it is necessary on occasion to make related repairs and to mitigate health and safety concerns which may not result in a decrease in energy use or in monetary savings. Therefore, as part of the Maine Weatherization Assistance Program, the following health and safety standards have been developed using DOE WAP Program Notice 11-6 with the objective of providing general guidance to agencies and subcontractors doing work within the program. All persons providing services under this program shall be governed by these requirements.

Allowable health and safety measures will be limited to measures that result from, or are worsened by, weatherization assistance, extend the durability or effectiveness of the weatherization measure, or are necessary to enable effective weatherization.

It is the responsibility of the agency to manage health and safety expenditures. Health and safety costs must be excluded from any SIR calculations and the per unit average, and must be tracked separately. Any Health and Safety measures that result in energy savings do not have to be tracked separately and should be included with the energy conservation measures. Any non-cost-effective tested health and safety measure should be reported as a separate line item on the computerized energy audit.

Each home weatherized must be individually assessed to determine the existence of potential hazards to weatherization personnel or clients. When

conditions within the home are such that the health and safety of the client, agency employees or, or contractor will be jeopardized prior to providing assistance, weatherization must not proceed until such problems are remedied. In some cases, mitigation of problems may be beyond the scope of the weatherization program. In these instances, the client must be notified in writing and referred to alternative resources for resolution of the problem.

In those instances where the existing conditions pose a threat to weatherization personnel health and safety, MaineHousing may waive portions of any audit or inspection process, installation, or any portion of the weatherization activity. Contact MaineHousing (EHS) in these cases.

Under these Standards, health and safety assessments of the following must be performed by the auditor:

1. Hazardous conditions and materials assessment, including, but not limited to:
    a. Friable asbestos.
    b. Unsafe levels of combustion byproducts, including carbon monoxide.
    c. Human or animal waste within the occupied dwelling.
    d. Lead paint in pre-1978 homes.
    e. Mold or mildew, dampness, or evidence of moisture.
    f. Evidence of pest problems.
    g. In homes where radon may be present:
        i. Provide the client with EPA's consumer guide to radon.
        ii. Whenever site conditions permit, exposed dirt must be covered with a vapor barrier ground cover, except for mobile homes. In homes where radon may be present, precautions must be taken to reduce the likeliness of making radon issues worse.
        iii. Radon mitigation is not allowed by DOE.
        iv. Radon testing is an allowable DOE expense.
2. Air quality assessment, including:
    a. Interviewing client(s) regarding health conditions of occupants with the intent of determining if air quality might be adversely affecting them.
    b. Determining ventilation needs for ensuring acceptable indoor air quality. Mechanical ventilation requirements shall be based on *Ventilation and Acceptable Indoor Air Quality in Low-Rise*

Residential Buildings, ASHRAE Standard 62.2-2010 if the building is three stories or fewer.

3. Combustion systems assessment, including:
   a. Combustion safety testing, including worst-case depressurization, spillage, draft, and carbon monoxide testing shall be done before and after weatherization work. If there is reason to be concerned about client safety – for example, the house has been significantly tightened, but the job has not been completed – it is recommended that worst-case depressurization testing be done during the work, just before the crew or contractor leaves the job site for the day.
   b. Fuel storage and fuel distribution hazards, including oil tank or propane storage problems and oil, propane, and natural gas distribution line leaks.
   c. Hazardous combustion appliance conditions.
4. Assessment of agency employees, contractor and client safety concerns.
   a. All materials stored on the job site for weatherization work must be must be stacked, organized, and properly marked so that it does not pose a hazard to clients, neighbors or weatherization personnel.
   b. All weatherization work must be performed in a manner that does not create a known hazard to clients, neighbors, or weatherization personnel.
   c. For pre-1978 homes, all weatherization work must be performed by individuals following EPA's Renovation, Repair, and Painting (RRP) rule and Lead-Safe Weatherization guidelines.

4.2 General

1. Correction of preexisting code compliance issues is not an allowable cost other than where weatherization measures are being installed. State and local codes must be followed when installing weatherization measures.
2. Correction of fire hazards is allowed when necessary to safely perform weatherization.
3. Pest removal is allowed only where infestation would prevent effective weatherization. Measured to limit pest entry to ensure the durability of weatherization measures is allowable.

   a. Infestation of pests may be cause for deferral where it cannot be reasonably removed or poses health and safety concern for workers.
   b. Screening of windows and blockage of points of pest access is allowed to prevent pest intrusion.

4. Removal of pollutants such as formaldehyde, volatile organic compounds, and other pollutants is required if they pose a risk to workers. If these pollutants pose a risk to workers and removal cannot be performed or is not allowed by the client, the unit must be deferred.
5. Repair and replacement of primary solid-fuel burning appliances is allowed when client health and safety is a concern. Maintenance and repair of secondary heating units (space heaters) is not allowed. Refer to Section 10.5 page 109 for more information.
   a. Providing fire extinguishers is allowed only when solid-fuel burning appliances are present.
6. Minor repairs such as repairing stairs, handrails, or replacing missing light bulbs, and may be done when necessary to effectively weatherize a dwelling.
   a. Workers must take all reasonable precautions against performing work on homes that will subject workers or occupants to health and safety risks.
   b. Minor repairs and installations may be conducted only when necessary to effectively weatherize a home.

4.3 Worker Health and Safety

1. It is the responsibility of the agency and/or the entity performing the weatherization work to initiate and maintain programs that comply with applicable Occupational Health and Safety Act Regulations (29 CFR 1910 & 1926) and any other applicable federal or state laws enacted to protect worker safety.
2. The agency and/or the entity performing the work must assess structural conditions and demonstrate caution when working in potentially dangerous areas.

4.4 Health and Safety Procedures

The following section establishes areas of concern that may affect the health and safety of the weatherization personnel and the clients. In most cases, the best

approach to limiting the health and safety risk is to minimize their exposure to the hazard. If weatherization personnel are unable to minimize their own exposure or the client's exposure to a hazard, work on the dwelling may have to be stopped.

MaineHousing expects weatherization personnel to be able to work under conditions that do not jeopardize their own health and safety. It also expects that these field personnel will use caution and care while working on the client's home. In addition, any office, warehouse or other workspace owned or rented by any agency or contractor should be a safe and healthy environment. For detailed information on worker health and safety, refer to *Construction Industry OSHA Safety and Health Standards* (29 CFR 1926/1910). The following are general guidelines for accident prevention and should be followed by weatherization personnel involved in weatherization work.

4.5 Workplace Safety Guidelines

1. It shall be the responsibility of the weatherization agency to initiate and maintain such directives and programs as may be necessary to comply with this Section.
2. The entity performing the work shall provide training in the area of health and safety, which will allow weatherization personnel to identify existing and potential threats to the client's, crew's, or contractor’s health and/or safety. Upon the identification of a threat to the client's health and/or safety, the client will be informed in writing as to the available options for mitigation.
3. The agency and/or contractor shall designate competent persons who will perform regular inspections of the job sites, materials and equipment.
4. The agency and/or contractor shall permit only those members of their crews qualified by training or experience to operate equipment and machinery.
5. The agency and/or contractor shall tag all machines, tools, materials, or equipment identified as being unsafe to those unqualified to operate them. The agency or contractor shall make these items inoperable when they are not in use by locking the controls or physically removing them from the work site.
6. The agency and/or contractor shall require their employees and representatives to take all reasonable precautions against performing work on homes that will subject clients to health and safety risks. At the time of initial client contact, the weatherization personnel will

make a cursory evaluation of the individual health of the home's occupants. In cases where a person's health is fragile and/or the crew's or contractor's work activities constitute a potential health or safety hazard for the occupant, the occupants will be asked to leave during the work activities.

Expenditure of weatherization funds for materials, protective clothing, respirators, medical exams, proper tools and equipment, and other items or activities related to the health and safety of clients and weatherization personnel are allowable health and safety costs under the Maine Weatherization Assistance Program.

1. When in doubt, agencies and contractors should seek consultation services from an OSHA subsidized professional safety consultant (See: OSHA Publication # 3047, *Consultation Service for the Employer*) to identify hazards and develop a worker health and safety program.
2. Agencies and contractors must have a health and safety policy in place. This program should contain the following:
    a. Material Safety Data Sheets (MSDS) on the job site and available to medical personnel.
    b. Crew members and subcontractors should know where to go for treatment.
    c. A written procedure for reporting medical emergencies.
    d. A written procedure for reporting non-emergency accidents.
    e. Provision for prompt medical attention for serious injuries.
        i. Prompt transportation or a system for contacting an ambulance.
        ii. Telephone numbers of physicians, hospitals, and ambulance services posted in a conspicuous location.
    f. A first aid program which includes, but not be limited to, the following:
        i. First aid training provided to at least one member of each agency's or contractor's crew.
        ii. CPR training provided to at least one member of each agency's or contractor's crew.
        iii. One complete first aid kit in each personnel vehicle.
        iv. One eyewash station with at least one refill per person.

3. Agencies and contractors must establish a personal protective equipment program. This program should include, but not be limited to, the following:
    a. Respiratory protection equipment and procedures that provide crew members and subcontractors with the following:
        i. The proper personal respiratory protection equipment.
        ii. Respirator fit testing by a trained person.
        iii. Training for agency and subcontractor crew members on respirator use.
        iv. Medical examination of pulmonary capacity, as frequently as recommended by appropriate OSHA standards.
    b. Eye protection that is appropriate and available when needed.
    c. Gloves and protective coveralls that are made available when needed.
4. Agencies and contractors should have in place a tool safety program designed to protect workers from workplace hazards. This program should ensure, but not be limited to:
    a. Tools are safe and adequate for the job.
    b. Ground-fault protection is provided for all power tools.
    c. Workers are trained in the safe and proper operation of tools and equipment used in their work.
    d. Safety guards are in place on all tools that come equipped with such devices.
    e. Ladders and scaffolding are adequate, have the proper weight rating, and are constructed of non-conductive material.
    f. Hearing/ear protection is provided to individuals working around high decibel equipment or in high dust environments.
5. It is preferred that agencies and contractors have a job hazards identification program. This program should include, but not be limited to, the following:
    a. Investigation of job-specific safety hazards.
    b. Hazard communication procedures that require:
        i. Written policies for dealing with job hazards.
        ii. That all hazardous materials containers are labeled:
            1. With the hazardous chemical contents.
            2. A hazard warning appropriate for worker protection.
            3. Legibly and prominently.

iii. A means for the exchange of information between agency crews and sub-contractors.

c. A catalog of Material Safety Data Sheets (MSDS) for all hazardous material that is made available to all clients, agency, and contractor employees, kept on file at the agency offices, and on all jobs sites. The MSDS catalog should contain the following:
   i. The chemical and common names of hazardous materials.
   ii. Physical and chemical characteristics of these materials.
   iii. Known acute and chronic health effects and related health effects.
   iv. Precautionary measures.
   v. Exposure limits.
   vi. Identification of carcinogens.
   vii. First aid procedures.
   viii. Poison control hotline telephone number, 1-800-222-1222.

6. Agencies shall establish a policy to certify their employees in lead-safe weatherization and to ensure contractor employees comply with EPA's Renovation, Repair, and Painting (RRP) rule.
7. At no time shall the contractor tap into a client's electrical box for an electric supply to run insulation blowing machines. Use of an existing dryer/stove electrical outlet is allowable with client written permission.

4.6 Client Health and Safety

1. Weatherization services must be provided in a manner that minimizes risk to clients. When an occupant's health may be at risk and/or the work activities could constitute a health or safety hazard, the occupant at risk will be required to take the appropriate action based on the severity of risk.
2. Health and safety issues should be addressed as part of the client education process, both verbally and by distributing educational pamphlets during the audit "walk-through". This can be particularly effective as the auditor notices and discusses potential hazards. The client education process should also identify other health or housing programs that might be able to provide services to address housing related health hazards.
3. Dwellings with unvented or vent-free combustion appliances, with the exception of gas ranges, may not be weatherized until such appliances are properly vented (according to the appropriate code) to

the outdoors or removed from the dwelling. Refer to Section 10.4 on page 108 for more information.

4. Building owners and clients must be notified in writing of any health or safety problems that require weatherization work to be postponed or terminated. Documentation of this notification must be included in the client file.
5. It is preferred that agencies and their contracted agents minimize or restrict the use of materials that may be hazardous to the client; however, if the agency or their contracted agent must utilize hazardous chemicals, it must be discussed with the client prior their use.
6. Special precautions must be taken if the occupant of the home has respiratory ailments, allergies, is pregnant, or has unique health concerns. Weatherization personnel should try to protect all clients from respirable particles, such as paint or insulation dust, Allergens, or other chemicals during the weatherization process.
7. The installation of hazardous materials must be performed in well-ventilated areas according to manufactures' specifications.
8. Weatherization personnel shall not smoke cigarettes, cigars, or pipes in a client's home or outdoors within 25 feet of the home.
9. If strong-smelling chemicals, such as formaldehyde, are detected in the client's home, agencies and their contracted agents should not perform any weatherization measures that will reduce the natural air leakage of the dwelling unless actions are taken to reduce the source of the chemicals. If the source of the chemicals cannot be mitigated, the work must be deferred.
10. At a minimum, auditors and weatherization personnel should inform property owners of safety problems, code problems and other health and safety issues. These items might include:
    a. Unsafe levels of carbon monoxide and other combustion appliance related hazards.
    b. Leaks of raw sewage from waste plumbing pipes.
    c. Hazardous levels of mold or moisture problems of concern.
    d. Mercury spills.
    e. Friable asbestos in an area that children frequent.
    f. Lead paint or lead in soil, for example, visible paint chips on play-area soil.

g. Storage of chemicals, pesticides, and products with volatile organic compounds in the living space that could be stored away safety to minimize occupant exposures.

4.7 Deferral of Service

There are some situations in which an agency or contractor should not, or may choose not to, weatherize an otherwise eligible unit. In order to deal with these situations, each agency and contractor will follow the MaineHousing Deferral of Services Policy that allows weatherization staff to postpone services when certain conditions or circumstances exist. At a minimum the deferral of service policy shall contain the elements listed below.

1. *Deferral of Weatherization Services:* An agency or contractor may postpone weatherization services under the following conditions:
   a. A dwelling unit is vacant.
   b. A dwelling unit is for sale.
   c. A dwelling unit is scheduled for demolition.
   d. A dwelling unit is found to have serious structural problems that would make weatherization impossible or impractical.
   e. A dwelling unit is deemed by the auditor to pose a threat to the health or safety of weatherization personnel.
   f. A manufactured home is improperly installed (for example, with inadequate supports).
   g. A dwelling unit is uninhabitable (for example, a burned-out apartment).
   h. The client is uncooperative with the weatherization agency or its contracted agent, either in demanding that certain work be done and refusing higher priority work which is needed, or by being abusive to the work crew or contractor, or by being unreasonable in allowing access to the unit. Every attempt should be made to explain the program and the benefits of the work. If this fails, work should be suspended and MaineHousing should be consulted.
   i. Obvious discrepancies are found between the information supplied by the client on the application and observed conditions at the time of weatherization. The agency or contractor must resolve these discrepancies before audit/weatherization work can continue.

j. If, at any time prior to the beginning of work (work officially begins when the audit is performed), the agency or contractor determines that the client is no longer eligible, or personnel believe that circumstances may have changed, the unit shall not be weatherized until updated information can be obtained from the client.
k. There are rats, bats, roaches, reptiles, insects, or other animals or vermin that are inadequately or not properly contained on the premises.
l. There are health or safety hazards that must be corrected before weatherization services may begin including, but not limited to:
    i. The presence of animal feces and/or other excrement.
    ii. Disconnected waste water pipes.
    iii. Hazardous electrical wiring.
    iv. The presence of unsafe levels of mold or mildew, or moisture.
    v. Unvented combustion appliances or actionable levels of ambient carbon monoxide.
    vi. Pre-weatherization combustion safety depressurization testing fails.
    vii. Presence of hazardous waste.
m. There are illegal drugs or illegal activities occurring on the premises.
n. The client or owner is physically or verbally abusive to any personnel.
o. The dwelling unit or parts thereof are being remodeled and could impact the effectiveness of the weatherization work and is not coordinated with a housing rehabilitation program.
p. The eligible household moves from the dwelling unit where weatherization activities and services are in progress. In such a case, the agency or contractor must determine whether to complete the work, and the circumstances must be documented in the client file.
q. One or more occupants in a dwelling have been diagnosed with a contagious disease or disease that is life-threatening to weatherization personnel.

There are unusual situations, which, in the judgment of the agency or contractor staff, must be corrected before proceeding with weatherization. The list above is not intended to be inclusive of all instances in which an agency or contractor may choose not to weatherize a unit. In some instances, corrective measures by the client/owner may allow program services to proceed.

1. Procedure:
    a. If an agency or contractor cannot, or chooses not to weatherize a dwelling unit, the client or owner/authorized agent must be notified with the use of the Deferral of Services Form, which must include:
        i. The nature and extent of the problem(s) and how the problem(s) relate(s) to the determination not to weatherize the dwelling unit;
        ii. Any corrective action required before weatherization services can be initiated;
        iii. A time limit for correcting problems so that weatherization services may be rescheduled;
        iv. The name of the person or entity responsible for correcting the problem(s);
        v. Available programs and/or services that might be able to assist the client in addressing the issues of concern; and
        vi. The right of appeal.
    b. All documentation justifying the decision to postpone services must be kept in the client file.

4.8 Combustion Appliances and Heating Systems

1. Repair and replacement of inoperable or unsafe combustion appliances is allowed, including the installation of direct-vent, sealed-combustion appliances.
    a. Repair and cleaning should be done before replacement is considered.
    b. Proper venting to the outdoors, including gas dryers and range hoods, is required.
        i. Correction of venting is allowed when testing indicates a problem.

2. System repair, replacement, or installation is allowed of red-tagged, inoperable, or nonexistent heating systems where climate conditions warrant.

4.8.1 Water Heaters and Other Appliances

1. Replacement of water heaters is allowed on a case by case basis.
   a. Replacement and installation of other appliances are not allowable health and safety costs.
   b. Repair and cleaning are allowed.

4.8.2 Stand-Alone Electric Space Heaters

1. Repair, replacement, or installation of stand-alone electric space heaters is not allowed. Removal is recommended. Check the electrical circuitry to ensure adequate power for existing space heaters.
2. Inform client of the hazards of use and have client sign a waiver if removal is not allowed by the client.
3. Stand-alone electric space heaters may be used as a temporary heat source during weatherization if the primary heating system is disabled.

4.9 Biologicals and Unsanitary Conditions

Remediation of a condition that may lead to or promote biological concerns or unsanitary conditions is allowed, however, addressing bacteria and viruses is not an allowable cost. Deferral may be required in cases where a known biological agent is present in a dwelling that may create a serious risk to weatherization workers.

4.10 Injury Prevention for Occupants

1. Minor repairs may be conducted when weatherizing a home in order to prevent injury to occupants. These minor repairs might include:
   a. Replacing missing light bulbs.
   b. Educate the client on how to lower the domestic hot water temperature.
   c. Repairing stairs, replacing handrails, and installing grab bars.

4.10.1 Preexisting Occupant Health Condition

When a person's health may be at risk and/or the work activities could constitute a health and safety hazard, the occupant at risk will be required to take appropriate action based on the severity of the risk.

1. The at-risk occupant should reveal their known or suspected heath concerns during the initial application for weatherization services.
2. The at-risk occupant should be provided with known risks of the weatherization process.
3. Worker contact information should be provided to the occupant so that occupant can easily provide information about health issues or concerns.
4. Failure or the inability to take appropriate actions must result in deferral of the weatherization work.

4.11 Spray Polyurethane Foam Use

Spray polyurethane foam is a widely used and highly-effective insulator and sealant; however, eye, skin, and inhalation exposures to its key ingredients can cause asthma, lung damage, other respiratory problems, skin and eye irritation, and other adverse health effects.

1. When working within the thermal envelope (for example, basements) with spray urethane foam, follow the EPA guidelines[3] with respect to occupancy and ventilation.
2. When using spray urethane foam outdoors, isolate the area where the foam will be applied, take precautions to ensure the fumes will not be transferred to the indoor living area.
3. Make sure all State and local fire codes are followed when spray polyurethane foam is used indoors.

4.12 Miscellaneous Health and Safety Rules

1. Replacement, repair or installation of windows or doors is not an allowable health and safety cost, but may be allowed as an incidental repair or an efficiency measure if justified by the MaineHousing approved software.
2. Replacement, repair, or installation of telephones is not an allowable cost.

[3] Please see http://www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html for detailed information.

   a. Provide client information about telephone replacement programs.
3. Vented space heaters should be treated as furnaces and should be tested similarly.

4.13 Asbestos Inspection Procedures

1. Prior to performing an energy audit, weatherization work, or conducting tests, the energy auditor must conduct an inspection for materials suspected of containing asbestos if there is the possibility that they may be disturbed during the weatherization testing or work.
2. Decisions on approaches to potential weatherization work where asbestos is present shall be based on the judgment of the most qualified individual at the agency or a MaineHousing representative. When major energy-saving measures might be sacrificed as a result of suspected asbestos-containing materials, the agency or contractor may have the suspected material tested for asbestos content.
3. All agency and contractor personnel must wear high quality respirators any time they are working with or near asbestos materials.
4. Materials containing asbestos may not be cut, drilled, or disturbed in any manner that may cause asbestos fibers to become airborne.
5. Agencies and contractors may not use abatement contractors to remove or dispose of asbestos-containing materials without prior authorization from MaineHousing.
6. On covering materials, such as steam pipe insulation, assume asbestos is present. Abatement – either removal or encapsulation – is allowed by a certified asbestos abatement contractor.
7. When vermiculite insulation is found in an attic, unless testing proves otherwise, take precautionary measures as if the vermiculite contains asbestos. Encapsulation by an appropriately trained asbestos control professional is allowed. Removal is not allowed. Blower door testing should be done with pressurization rather than depressurization.

4.14 Lead Safe Weatherization (LSW)

All participants working in the Weatherization Assistance Program shall follow EPA's Lead, Renovation, Repair and Painting Program (RRP). In addition to RRP, Weatherization requires all weatherization crews working in pre-1978 housing to be trained in Lead Safe Weatherization (LSW). Deferral is required

when the extent and condition of lead-based paint in the house would potentially create further health and safety hazards. Testing for lead based paint is allowed.

Each agency must give notification to the occupants of homes to be weatherized regarding the potential hazards of lead paint and lead paint dust if the home was built prior to 1978. EPA's publication "Renovate Right: Important Lead Hazard Information for Families, Child Care Providers and Schools" must be given to an adult occupant of the affected home. For occupied homes, the agency or their representative must have an adult tenant or homeowner sign an acknowledgement after receiving the pamphlet. The pamphlet can also be sent by certified mail with receipt to be placed in the customer file.

Lead-Safe Weatherization (LSW) includes weatherization worker protection, general LSW work practice standards, and lead dust containment standards.

1. Level 1 Containment.
    a. Level 1 containment is required in pre-1978 homes when less than 6 ft^2 of interior painted surface per room or 20 ft^2 of exterior painted surface will be disturbed.
    b. Level 1 containment consists of methods that prevent dust generation and contains all debris generated during the work process. The containment establishes the work area which must be kept secure.
    c. Measures that may fall within this guideline include:
        i. Installing or replacing a thermostat.
        ii. Drilling and patching test holes.
        iii. Replacing HEPA filters and cleaning HEPA vacuums.
        iv. Changing furnace filter.
        v. Removing caulk or window putty (interior).
        vi. Removing caulk or window putty (exterior).
        vii. Removing weatherstripping.
2. Level 2 Containment.
    a. Level 2 containment is required when Weatherization activities will disturb more than 6 ft^2 of interior surface per room or 20 ft^2 of exterior surfaces in homes built prior to 1978. Level 2 containment consists of methods that define a work area that will not allow any dust or debris from work area to spread. Level 2 containment requires the covering of all horizontal surfaces, constructing barrier walls, sealing doorways, covering HVAC

registers with approved materials, and closing windows to prevent the spread of dust and debris.

b. Measures requiring level 2 containment may include:
   i. Drilling holes in interior walls.
   ii. Drilling holes in exterior walls, removing painted siding.
   iii. Cutting attic access into ceiling or knee walls.
   iv. Planing a door in place.
   v. Replacing door jambs and thresholds.
   vi. Replacing windows or doors.
   vii. Furnace replacements.

c. 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):
   i. Window replacement.
   ii. Demolition of painted surface areas.
   iii. 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.

3. 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.
4. 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.
5. 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.

6. 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 insurance, or alleviate existing mold conditions identified during the audit, the work performance period, or the quality control inspection.

If existing mold or mildew problems are beyond the scope of the weatherization program and should be addressed prior to weatherization work, the weatherization work must be deferred until the related hazards are corrected.

If a mold condition is discovered that will defer or prevent weatherization services, the client must be notified in writing of the moisture or mold condition. Use the Deferral of Services form to clearly delineate the perceived problem and indicate who will be responsible for its remedy. The Deferral of Services Form must be reviewed and signed by the client and/or landlord.

4.15.2 Assessment of Moisture Conditions

All homes should be checked for previous or existing moisture problems.

1. The moisture assessment section of the Maine Field Form must be filled out with special attention to the following:
    a. Evidence of condensation on windows and walls indicated by stains or mold.
    b. Standing water, open sumps, open wells, dirt floors, water stains, etc. in basements. Also, check to see if firewood is stored in the

basement and whether laundry is hung to dry indoors during the winter months.

c. Leaking supply or waste pipes.
d. Attic roof sheathing that shows evidence of mold or mildew.
e. Client-provided information.

2. Identification of existing or potential moisture problems shall be documented in the client file.
3. If existing moisture problems are found, no air sealing should be done unless the source of the moisture can be substantially reduced, or effective mechanical ventilation can be added to remove the moisture. In some cases, air sealing must be done in order to reduce the source of the moisture (i.e., sealing off crawl spaces from the house, or sealing an attic floor to eliminate condensation on the roof deck).
4. Because air tightening may cause an increase in relative humidity, the client should be informed about moisture problems and possible solutions.
5. In the course of weatherization, any low-cost measures that help reduce the humidity and moisture levels in the house should be installed. Examples of these measures are venting dryers, venting existing bath or kitchen exhaust fans, or installing moisture barriers on dirt floors, modest grading or repairs to gutters and downspouts to direct rain and snow moisture away from the structure.

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 on page 33 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 62.2-2010, *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 building of three stories or fewer. If the building under consideration is four stories or more, ASHRAE Standard 62.1-2010 should be used (this ASHRAE standard is not addressed in the Maine Weatherization Standards).

Existing operable fans that will remain in place and serve as part of the ventilation system shall be measured for CFM airflow. This airflow shall be recorded on the appropriate form.

4.16.1 Bathroom Ventilation

1. Should have on-demand fans that exhaust at least 50 CFM and are controlled by an on/off switch or a time-delay-shutoff switch; or

2. Should have continuously operating 20 CFM fan.
    a. A continuously operating bathroom fan or a programmed intermittently operating fan may serve as the whole-building ventilation.
3. If a bathroom does not have this amount of ventilation stated in 1.a. or 1.b. above, it must be provided, or Appendix A of ASHRAE 62.2-2010 must be used for sizing whole-building ventilation.
4. Installed fans must have a back-draft damper at the fan, at the duct termination, or at both locations.
5. The duct termination must be outdoors.
6. Fan flows of existing bathroom fans that are to be left in place must be measured or the flow rate shall be determined by the fan label according to ASHRAE 62.2-2010 requirements (see ASHRAE 62.2-2010, Section A4.2).

4.16.2 Kitchen Ventilation

1. On-demand exhaust fan:
    a. Should have on-demand fans that exhaust at least 100 CFM and are controlled by an on/off switch.
    b. The fan may be located anywhere in the kitchen, but a range hood or a fan location near the range is preferred.
2. Continuously-operating exhaust fan:
    a. Should have continuously operating fan that exhausts at least 5 ACH based on kitchen volume. A continuously operating kitchen fan or a programmed intermittently operating fan may serve as the whole-building ventilation.
        i. A continuously operating kitchen fan or a programmed intermittently operating fan may serve as the whole-building ventilation.
3. If a kitchen does not have the amount of ventilation stated in 2.a. or 2.b. above, it must be provided, or Appendix A of ASHRAE 62.2-2010 must be used for sizing whole-building ventilation.
4. Installed fans must have a back-draft damper at the fan, at the duct termination, or at both locations.
5. The duct termination must be outdoors.
6. Fan flows of existing kitchen fans that are to be left in place must be measured or the flow rate shall be determined by the fan label

according to ASHRAE 62.2-2010 requirements (see ASHRAE 62.2-2010, Section A4.2).

7. Outdoor make-up air should be provided for kitchen fans exhausting more than 200 CFM.

4.16.3 Whole-Building Ventilation

Whole-building ventilation operating continuously shall be no less than 7.5 CFM per person + 1 CFM per 100 ft2 of conditioned floor area. If the number of people living in the dwelling is not known, or if the number of bedrooms plus 1 is greater than the number of people, the number of bedrooms plus 1 shall be used to determine the occupant number.

1. This ventilation may operate intermittently, but
   a. The CFM airflow must be increased accordingly while the fan is operating. For example, a flow rate of 25 CFM for continuous operation would be increased to 50 CFM for 30 minutes-on/30-minutes-off operation.
   b. The fan must operate at least once every 4 hours.
   c. The fan must be controlled automatically.
   d. The fan control must be appropriately labeled.
2. If the bathroom and/or kitchen fans do not satisfy the requirement of 50 CFM and 100 CFM airflow rates, respectively, Appendix A of ASHRAE 62.2-2010 (Alternative Compliance Supplement) must be used when sizing the minimum whole-building airflow rate.
3. The whole-building ventilation may be a single exhaust fan; multiple exhaust fans controlled appropriately; a balanced systems, such as a heat recovery ventilator; or part of the furnace air handling system.
   a. Local bathroom and/or kitchen exhaust fans are permitted to be part of the whole-building ventilation system.
   b. The system must be designed to operate during all occupiable hours.
   c. A readily available override control must be provided to the occupant.
   d. Whole-building minimum ventilation requirements shall be determined by methods acceptable to MaineHousing.
   e. The infiltration credit shall be calculated as part of the procedure and be based on ASHRAE 119-1988 and 136-1993, and

f. The alternative compliance supplement (Appendix A of ASHRAE 62.2-2010) shall be included when bathrooms or kitchens do not meet the local ventilation requirements.

4.16.4 Whole-Building Ventilation Discretionary Threshold.

1. If the whole-building minimum ventilation requirement is 15 CFM or less, the energy auditor may decide to install a whole-building ventilation system or not. The reasons for not installing a ventilation system when the minimum CFM requirement is between 1 and 15 shall be documented in the client file. This decision shall be based on:
   a. The moisture assessment of the dwelling,
   b. The indoor air quality assessment of the dwelling,
   c. The health of the occupants, and
   d. Other factors deemed significant by the energy auditor.
2. If the whole building minimum ventilation requirement is greater than 15 CFM, a system supplying the minimum ventilation airflow must be installed.

4.16.5 Fan sound ratings

1. Fan sound ratings shall be equal to or less than the ratings in Table 4-1.

Table 4-1

Maximum Fan Sound Ratings		
New Replacement Fans	***Existing Retained Fans***	***Maximum Sound Rating***
Local bath, on-demand		3.0 sones or 50 dBA*
	Local bath, on-demand	N/A
Local bath, continuous		1.0 sone or 30 dBA*
	Local bath, continuous	N/A
Local kitchen, on-demand		3.0 sones or 50 dBA*
	Local kitchen, on-demand	N/A
Local kitchen, continuous		1.0 sone or 30 dBA*
	Local kitchen, continuous	N/A
Whole-building		1.0 sone or 30 dBA*
	Whole-building	1.0 sone or 30 dBA*

* A-weighted decibels measured at 5 feet from fan grille.

Source: ASHRAE 62.2-2010.

4.16.6 Ductwork

1. Ducts outside of the thermal envelope shall be insulated to a minimum of R-8.
2. Rigid ductwork with a smooth interior surface is recommended over flexible ductwork.
3. Duct support
   a. Rigid ducts will be supported at intervals of 4 feet or less. Supports shall have a width of at least 1 ½ inches.
   b. Flexible ducts will be supported at intervals of 2 feet or less. The maximum amount of support between supports shall be ½ inch per foot of horizontal run, or less. Supports shall have a width of at least 1 ½ inches.
4. Duct diameter will be equal to or greater than the exhaust fan outlet.
5. Duct runs shall be as short as possible and shall have not more than one elbow of a maximum of 90 degrees.
6. Kitchen fan ductwork shall be rigid, smooth metal of at least 30-guage wall thickness.
7. Rigid duct requirements:
   a. Metal-to-metal or metal-to-PVC connections shall be fastened with a minimum of at least three equally spaced screws.
   b. PVC-to-PVC joints shall be joined with approved PVC cement.
   c. In addition to mechanical fasteners, seal duct connections with UL 181B or 181-M listed material. Exception: PVC connections.
   d. Rigid ductwork shall be sized according to Table 4-2.
8. Flexible duct requirements:
   a. Shall not be bent around framing members of other objects.
   b. Extend flex duct to its fill length so that the excess length is no more than 5 percent.
   c. When flex duct is run through confined spaces, do not reduce the diameter of the flex duct in order to fit it within the space.

d. Repair tears in flex duct vapor barrier using the manufacturer's recommended material.
e. Attach sections of flex duct according to the manufacturer's recommendations.
f. Flex-to-metal or flex-to-PVC joints shall be fastened with tie bands using a tie band tensioning tool.
g. Flexible ductwork shall be sized according to Table 4-2.

Table 4-2

Prescriptive Duct Sizing*								
Duct Type	**Flex Duct**				**Smooth, Rigid Duct**			
Fan Rating, CFM[+]	50	80	100	125	50	80	100	125
Duct Diameter, inches	**Maximum Length, feet**							
3	X	X	X	X	5	X	X	X
4	70	3	X	X	105	35	5	X
5	NL	70	35	20	NL	135	85	55

* This table assumes no elbows. Deduct 15 feet of allowable duct length for each elbow.
[+] Fan rating @ 0.25 inches of water column.
NL = no limit on duct length of this size.
X = not allowed, any length of duct of this size with assumed turns and fitting will exceed the rated pressure drop.
Source: ASHRAE 62.2-2010, Table 5.3, page 6.

9. Duct terminations, exhaust
    a. The termination collar shall be at least the same equivalent size as the exhaust fan outlet.
    b. Termination fasteners shall not inhibit damper operation.
    c. Exterior termination will be flashed or weather sealed.
    d. Galvanized hardware cloth with no less than ¼ inch and not greater than ½-inch hole size will be used to exclude pests.
    e. Terminations shall be at least 3 feet from any property line or any operable opening in houses and at least 10 feet from any mechanical inlet.
    f. Metal or other approved material shall be used for the termination fitting for kitchen exhaust.

g. All existing mechanical exhaust ventilation systems should terminate outside the building shell by extending the ventilation duct through the roof, sidewall, foundation, or skirting.
h. Installed fans must have a back-draft damper at the fan, at the duct termination, or at both locations.

10. Exhaust grille location:
    a. For local bathroom or kitchen exhaust, the fan and/or grille shall be installed in the space where contaminants are generated.
    b. For whole-building ventilation when other local bathroom and/or kitchen ventilation is present, the grille should be located central location within the main body of the dwelling.
    c. For whole-building ventilation when no local ventilation is present, the grille should be installed in the central bathroom with the highest moisture generation.

4.16.7 Instructions, Labeling, and Client Education[4]

1. A ventilation system operation guide designed for the occupants (non-professionals) to explain why the system was installed and how to operate and maintain the system.
2. This guide shall be reviewed with the occupants.
3. Controls shall be labeled as to their function, unless that function is obvious (such as on-demand bathroom exhaust switches).Clients shall be asked to sign a document[5] attesting to the fact that they have been informed about the importance and proper use of installed ventilation devices.

4.16.8 Commissioning

1. Airflows of local bathroom and kitchen fans and whole-building fans shall be measured after installation by the agency to ensure that the design CFM airflow has been achieved.

4.17 Smoke Alarms

1. Installation of smoke alarms is allowed where smoke alarms are not present or are inoperable.

[4] Please refer to ASHRAE Guideline 24-2008, Chapter 13, Operations and Maintenance Documentation, for guidance.
[5] The title of this document will be determined in the near future.

4.18 Carbon Monoxide (CO)

4.18.1 Measurement of Carbon Monoxide

1. MaineHousing views any ambient CO as potentially hazardous.
2. If ambient CO levels in excess of 9 ppm are discovered, the source of the CO must be found and corrected before any weatherization measures are installed.
3. Ambient carbon monoxide shall be measured in all dwellings with combustion appliances pre- and post-weatherization. Results must be documented in the field form.
4. Ambient CO shall be measured during all combustion safety testing, including worse-case depressurization and gas range testing.
5. CO emissions must be measured:
    a. In oil- and gas-fired vented combustion appliances.
        i. For combustion appliances vented into a chimney or approved metal vent, CO must be measured during combustion safety testing in the vent connector before dilution air enters the venting system. A Limited Energy Auditors Technician license is required in order to take these measurements.
        ii. For combustion appliances vented through a wall, CO must be measured during combustion safety testing at the vent termination outdoors. A Limited Energy Auditors Technician license is not required in order to take these measurements.
    b. In gas-fired ranges, including range top burners and ovens. Measurement of CO emissions from gas range burners is not required by this Standard; however, measurement of these emissions is allowable and is recommended when the energy auditor thinks it is prudent to do so. A Limited Energy Auditors Technician license is not required in order to take these measurements.
    c. Around solid-fuel burning appliances, including wood, pellet, and coal space heaters and cook stoves. The only acceptable method for testing CO emissions from solid fuel appliances is by testing the ambient air close to the appliance for CO

concentrations. If ambient levels are higher than 9 ppm, action to repair or replace the appliance must be taken.

d. Ambient CO should be measured in the room in which oil- or gas-fired furnaces or boilers are installed. Ambient measurements should be taken approximately five feet above the floor. If ambient levels exceed 9 ppm, action must be taken to repair or replace the problem unit immediately and appropriate client education must be administered.
e. If the measured CO levels in the vent connector are higher than 100 ppm as-measured or 200 ppm air-free, action to clean, repair, or replace the appliance must be taken.

4.18.2 Carbon Monoxide Alarms

1. When a dwelling has any combustion appliances and no operable CO alarms are present, at least one carbon monoxide (CO) alarm must be installed in the dwelling prior to weatherization measures being installed, regardless of any existing CO alarms in the dwelling. Follow the manufacturer's recommendations for location and installation of the alarm.
2. All CO alarms installed shall be the equivalent to the latest Underwriters Laboratory standard (ANSI/UL 2034). Installed CO alarms may be used that alarm at a lower concentration of CO.

4.19 Unvented Space Heaters

1. A dwelling utilizing an unvented space heater cannot be weatherized.
2. Removal is required of an unvented space heater serving as the primary source of heat.
   a. If a unit serves as a secondary heat source and conforms to ANSI Z21.11.2[6], it may remain in place.
   b. Primary units that do not meet ANSI Z21.11.2 must be replaced. After replacement, weatherization may take place.
3. In such cases, the Deferral of Services Form must be signed by the client.
4. The energy auditor must explain the consequences of using an unvented space heater to the client.

[6] Gas-Fired Room Heaters - Volume II, Unvented Room Heaters.

5. When the client has agreed in writing that they understand the policy and will not use the unvented space heater as their primary heating source, weatherization may commence.

4.20 Exceptions

1. In all cases, it is the auditor's responsibility to determine if a condition exists that could cause any diagnostic equipment or test procedure to be potentially harmful to clients or weatherization personnel.
2. Diagnostic equipment or test procedures should not be used in or on dwellings where such equipment or testing could exacerbate existing problems or pose a threat to the health of occupants.
3. If the potential exposure can be eliminated by varying the test procedure while still achieving reliable results, doing so is permissible and encouraged. For example, in a home with possible airborne pathogens, pressurizing as opposed to depressurizing during the blower door test should garner the necessary data safely. If no viable alternate test procedure exists, elimination of the test in question is allowable in the subject home.
4. All required testing shall be done to the extent allowed by law.
5. Exceptions must be documented in each client file.

5 Client Education

5.1 Client/Owner Education Recommendations

1. Client education should be provided during all phases of the weatherization process. This includes, but is not limited to:
    a. During client intake and scheduling, education should cover:
        i. What the client should expect.
        ii. How the weatherization process will proceed.
        iii. Who will call the client next.
    b. During the initial field audit, education should address:
        i. What the client should expect during the energy audit.
        ii. Air leaks discovered with the blower door.
        iii. Health and safety issues should be addressed as part of the client education process both verbally and by distributing educational pamphlets during the audit “walk-through. This can be particularly effective as the auditor notices and discusses potential hazards. An explanation of any appropriate health and safety issues, such as:
            1. Lead paint and other lead hazards.
            2. Asbestos.
            3. Combustion safety.
            4. Carbon monoxide.
            5. Mold and mildew or moisture.
            6. Ventilation.
            7. Plumbing leaks.
            8. Animal hazards such as rodent feces or insect infestations.
            9. Contaminants from storage and use of chemicals, pesticides, and other potential hazardous products.
            10. Other possible hazards.
        iv. An explanation of energy-conserving measures that will be installed.
            1. Air sealing.
            2. Addition of insulation.
            3. Heating system improvements.

4. Baseload measures, including water heating improvements.

v. Improvements in thermal comfort and safety in the dwelling as a result of the weatherization.

vi. Explanation of gas range safety and use. Refer to Section 12.4 on page 133.

vii. An explanation of required maintenance for existing equipment, added equipment, or energy-saving measures, including smoke and carbon monoxide alarms.

viii. What will take place after the energy audit:
   1. Overview of events and approximate work timeframe.
   2. Who will contact client next.
   3. When the work will be completed.

ix. What the client must do to prepare for the weatherization work.
   1. Movement of stored items to make room for the weatherization work.
   2. Other client participation that must take place before the weatherization work begins.

x. The auditor must obtain a client-signed copy of the Client Education checklist.

c. The installation and repair of conservation measures.
   i. Those installing weatherization measures should always take advantage of client education opportunities. Such opportunities may include explaining how and why a measure is being installed.

d. The final job inspection.
   i. The inspection personnel should reinforce the advantages of the energy-saving measures installed.
   ii. The client should always be asked if they have any remaining questions regarding the weatherization or health and safety work that was done.
   iii. The inspection personnel should explain to the client how the dwelling will perform differently as a result of the installed weatherization measures. This should emphasize exhaust devices and their potential impact on the safe operation of combustion appliances.

2. Whenever possible, demonstrate to educate. Get the client involved in the educational process, if possible.
3. The use of up-to-date written materials for client education.

6 Air Sealing

6.1 Air Sealing Requirements

Before air leakage reduction measures are installed, the thermal and pressure boundaries of the building envelope must be defined and existing health and safety problems must be corrected.

During the air sealing process, a blower door should be set up so that the effectiveness of air sealing can be determined by measuring the reduction in the dwelling CFM_{50} value. This should be done at least two times during air sealing.

Usually, as air sealing work progresses, it becomes less cost effective because the large leaks are sealed first. When it seems that the effectiveness of air sealing has diminished to a point below that which is cost effective, the sealing work should stop.

Energy auditors and weatherization crews and contractors are advised to use infrared scanning whenever the use is practical.

6.2 Blower Door Guided Air Sealing

6.2.1 Gross and Guided Air Sealing

In progress monitoring of air sealing measures is required and can be performed by the crew chief, contractor or energy auditor. This shall include monitoring of air sealing tasks and performing blower door guided air sealing. Insulation tasks shall not commence until acceptable air sealing has been verified. MaineHousing strongly recommends contractors perform air sealing tasks with the guidance of the blower door.

Air sealing work on dwellings is of two types:

1. *Gross air sealing.* Examples include replacing window glass where glass is missing, and sealing gross holes in the building envelope. There is little question that sealing or repairing these gross holes in the dwelling envelope will be cost-effective.
    a. Prior to any work done on the dwelling, an “as-is” blower door test should be performed as a means of finding these gross holes. This test will indicate whether gross air sealing is needed before a more representative blower door test can be made.

2. *Guided air sealing.* This is air sealing completed with the guidance of the blower door. Operate the blower door in depressurization mode while inspecting for leaks, however, it is often better to pressurize the dwelling when inspecting for leaks in an attic. Do not forget to check for leaks in a conditioned basement. Air sealing work is usually cost-effective only up to a point. Once that point is reached, air-sealing work should cease. Stop air sealing when:
   a. The higher of the following CFM_{50} values is reached:
      i. The Air Sealing Target (AST) CFM_{50} value is reached (refer to Section 14.2 on page 146). The lowest AST shall be 1000 CFM_{50}.
      ii. The Depressurization Tightness Limit (DTL) CFM_{50} value is reached. Refer to Section 14.3 on page 147.

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 14.1, page 144 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.
   i. Other obvious holes or leaks in the dwelling envelope that:
      i. Are cost-effective to seal,
      ii. Will prevent the structure from damage, or
      iii. Are necessary for the proper installation of insulation.
3. Openings in recessed light fixtures must not be sealed unless the fixture is rated as a type “IC” fixture.
4. Fire stopping around masonry chimneys “shall be of galvanized steel not less than 26-gauge thick or of noncombustible sheet material not more than ½ inch thick.”[7] Such material must be used to seal gaps or chases greater than ¼ inch wide around masonry or metal chimneys. Aluminum flashing may not be used for this purpose. This fire-rated material must be sealed to the chimney and the surrounding framing and finish materials with high temperature caulking. Gaps of ¼ inch or less are to be sealed with high temperature caulking only. This treatment is intended to stop the flow of air and water vapor into the attic from these gaps or chases.

[7] NFPA 211 *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*.

a. In addition to stopping the flow or air around a chimney, a dam must be installed to keep insulation at least 2 inches from the masonry or metal chimney. This is to be accomplished with a block of a rigid material. If this material is not fire-rated, it must be at least two inches from the masonry or metal chimney.
b. If an existing chimney or flue is treated incorrectly, correct it to comply with these standards. If it is not reasonable to bring a chimney up to these standards, consider deferral of services until the condition is corrected.

6.3.2 Penetrations in Basement Ceilings

1. If the basement is defined as an unconditioned zone, seal all significant leaks in the basement ceiling. Sealing penetrations between a conditioned (the first floor area) and an unconditioned space (the basement) is allowable and saves energy.
   a. Use the blower door to help find leaks in the ceiling by depressurizing the house, closing the door to the basement, and opening a basement window or door to the outside.
2. If the basement is defined as a conditioned zone (within the thermal/pressure envelope), leaks that are not connected to the outdoors should not be sealed. Sealing leaks between conditioned zones is not allowable. However, some penetrations in a basement ceiling, while initially appearing to be between two conditioned zones, might be connected to the outdoors through attics, open interior walls, exterior walls, or unconditioned attached structures. These circuitous leaks are more likely found in a balloon-framed house. Leaks of this type must be sealed. Follow this procedure to identify circuitous basement ceiling leaks that are connected to the outdoors:
   a. First, carefully complete all attic bypass air sealing.
   b. Insulate the attic after completing the attic bypass air sealing.
   c. Insulate the house walls. The walls must be dense packed with cellulose unless conditions will not permit.
   d. Depressurize the dwelling with the blower door.
   e. With the blower door running, the door to the interior basement open, and the basement doors and windows closed to the outdoors, search for leaks in the basement ceiling connected to the outdoors. If air is flowing through penetrations in the basement ceiling, the penetration is connected to the outdoors. Possible examples of this type of leak include:

i. Chimney chases.
ii. Plumbing stacks.
iii. Interior walls open to the basement.

f. If basement ceiling penetrations are leaking air from the outdoors, seal them. Note: It is always best to stop these circuitous leaks by sealing attic bypasses or dense packing exterior walls with cellulose. However, in some cases, difficult air leaks remain after this work. Sealing them in the basement might be the only option.

6.4 Room-to-Room Pressures

1. 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 installations have been completed, but before a worst-case depressurization test is performed. Room-to-room pressure differences while the air handler is operating and the door between rooms is closed should be 3 Pascals or less. Please refer to Section 14.4.3 on page 151 for detailed instructions.

6.4.1 Fireplace Plugs and Whole House Fans

1. Removable fireplace "plugs" should be installed in a manner that prohibits the use of the fireplace when the "plug" is in place.
   a. Appropriate and visible warning signage must be installed.
2. Covers for whole house fans should be easy to remove and reinstall.

6.4.2 Window Air Conditioners

1. Window air conditioners should be removed and stored when not needed. When it is found that the client does not remove a window air conditioner for the heating season, client education should address the advantages of:
   a. Removing and closing the window, or
   b. Installing an airtight cover on the exterior of the air conditioner unit, or
   c. Sealing the air conditioner unit from the interior.

6.5 Zone Pressure Diagnostics

1. Zone Pressure Diagnostics (ZPD) testing to assist in the determination of the location of pressure boundaries of the dwelling, the effectiveness of air sealing measures, and indoor air quality

concerns is an effective tool. Please refer to Section 14.9 on page 163 for the details of ZPD procedures.

2. ZPD testing is required for:
   a. Verifying the effectiveness of attic air sealing.
      i. Post-weatherization leakage between the house and the attic (house-to-zone using add-a-hole ZPD method) should be 30 percent or less of the attic floor area. For example, an attic floor area of 1000 ft^2 should be tightened to 300 CFM_{50}.
      ii. If this air leakage cannot be measured with ZPD methods, the reason must be documented in the client file.
      iii. If this air leakage cannot be measured with ZPD methods, the reason must be documented in the client file.
   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 weatherization measures.
      i. Post-weatherization leakage between the house and garage (house-to-zone using open-a-door ZPD method) should be 200 CFM_{50} or less.
      ii. Exceptions:
         1. If the garage has been converted to a living space, this testing is not required.
         2. If the garage is not able to be fully enclosed, this testing is not required.
         3. The configuration of the attached or tuck-under garage makes ZPD testing impossible. For example, if an attached garage is also connected to the dwelling attic space. In such cases, the reason for not testing must be included in the client file.
      iii. If this air leakage cannot be measured with ZPD methods, the reason must be documented in the client file.

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. 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 attic.
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.
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:
    b. MaineHousing requires that knob-and-tube wiring be deactivated if the additional cost of doing so, when added to the cost of insulation, results in an SIR for attic insulation installation of one or greater. If the additional costs of deactivation results in an SIR less than 1.00, than the Deferral of Services Form shall be completed.
    c. 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.
2. The inspection must include a determination of the R-value and integrity of existing insulation, the location of air leaks from the conditioned spaces to the attic, and the suitability of the structure for receiving insulation.
3. The inspection should determine the necessity of any repair work associated with the installation of the attic insulation. Repairs should be completed before installing insulation.

7.2.2 Moisture Inspection and Repair

1. Roof leaks and all other attic moisture problems shall be repaired prior to the installation of attic or roof insulation.
2. All mechanical vents from exhausting and combustion appliances must be vented through the roof or sidewall to the outside.

7.2.3 Treatment of Other Hazards

1. Use appropriate personal protective equipment and work practices to ensure personal safety during work.
2. Repair any rotted, broken, or damaged attic structural components. Ensure that the ceiling will safely hold the weight of the insulation. Repair or replace any weakened, damaged, or missing interior ceiling material.

7.2.4 Attic Access

1. When it is necessary to install an interior attic access in the ceiling and it is not structurally prohibited, it must be:
   a. At least 4 square feet, and
   b. At least 20 inches in width or length, and
   c. Shall be weatherstripped, have tightly latching hardware, and be insulated to the same level as the attic floor, or with at least 4 inches of extruded polystyrene (R-20).
2. An attic ceiling access shall have an insulation dam, made of rigid materials, that exceeds the height of the insulation to be installed.

The dam must be strong enough to hold the weight of a person entering or exiting the attic.

a. Examples of approved attic access insulation dam materials include:
    i. Plywood of at least ¾ inch thickness.
    ii. Wood board of at least ¾ inch thickness.
    iii. Plywood of at least ½ inch thickness with ¾ inch by 2-½ inch strapping securely fastened to the exterior face of the plywood box, with the edge of the strapping flush with the top edge of the fabricated plywood box.

3. If there are no interior accesses, at least one exterior access to each attic space shall be left accessible for inspection purposes. Before such access is sealed, the attic and/or knee wall area must be inspected by an appropriate agency or MaineHousing representative. This inspection must be adequately documented in the client file.
4. When it is necessary to install an interior access in a knee wall, it must be at least the width of the knee wall stud cavity by 24 inches high, and shall be weatherstripped and insulated to the same R-value as the knee wall. At least one latch shall also be installed to ensure air tightness. In pre-1978 homes, lead-safe work and clean-up practices shall be utilized.
5. Existing attic hatches may be upgraded when possible and shall comply with the standards of this section. Upgrading of existing attic hatches shall be billed accordingly by actual materials installed and only allowed when deemed cost effective.

7.2.5 Insulation Shielding and Blocking

1. No insulation, including fire-rated insulation, shall be installed above non-IC rated light fixtures so as to trap heat or prevent free air circulation. However, insulation may be installed over Type IC (insulation contact) light fixtures. All electrical boxes/fixtures shall be flagged above any added insulation.
2. Blocking must be installed so that it is effective in shielding the insulation from the heat source, and no insulation shall be left within the blocked area.
3. Metal blocking must be notched so that it does not contact electrical wiring.

4. If insulation is added to the attic, rigid permanent blocking is required around the attic access openings.
5. Fire stopping around masonry chimneys "shall be of galvanized steel not less than 26-gauge thick or of noncombustible sheet material not more than ½ inch thick."[8] Such material must be used to seal gaps or chases greater than ¼ inch wide around masonry or metal chimneys. Aluminum flashing may not be used for this purpose. This fire-rated material must be sealed to the chimney and the surrounding framing and finish materials with high temperature caulking. Gaps of ¼ inch or less are to be sealed with high temperature caulking only. This treatment is intended to stop the flow of air and water vapor into the attic from these gaps or chases.
    a. In addition to stopping the flow or air around a chimney, a dam must be installed to keep insulation at least two inches away from the masonry or metal chimney. This is to be done with a block of rigid material. If this material is not fire-rated, it must be at least 2 inches from the masonry or metal chimney.
    b. If an existing chimney or flue is sealed or dammed incorrectly, correct it to comply with these standards. If it is not reasonable to bring a chimney up to these standards, document this fact in the client file and include photographs.
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.

[8] NFPA 211 *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*.

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. Attics shall be tested using zone pressure diagnostics when the housing construction type or the air leakage rate indicates that there may be hidden air leaks or bypasses into the attic. This test shall be conducted prior to, and then after, installing insulation in order to determine the quality and completeness of the air leakage and bypass sealing. Please refer to Section 14.9 on page 163 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 at least two depth gauges located in a manner that will demonstrate the depth throughout the attic.
    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. Settled insulation depth.

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 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

1. 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 11.1.4 on page 119 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

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

7.2.13 Attic Ventilation

7.2.13.1 *General Installation*

1. Ensure that existing vents are not blocked, crushed, or otherwise obstructed. Correct problems as necessary, or replace.
2. When attic insulation is installed, a reasonable amount of attic ventilation should be in place, unless local codes supersede.
3. Roof vents should be nailed and well-sealed to the roof to prevent water leakage. If possible, roof vents should be located on the areas of the roof least visible from the ground.
4. All ventilation openings should have suitable louvers and screens to prevent snow, rain, and insects from entering the attic.

7.2.13.2 *High-Low Vents*

1. Roof and dome vents should be installed close to the peak.
2. Install high gable vents with a horizontal projection of at least three feet above the soffit or a gable vent used for low venting when possible.

7.2.13.3 *Gable Vents*

1. Gable-end vents should be installed as high in the gable as possible and positioned to provide cross ventilation.
2. Precautions shall be taken to prevent the wind from "washing" insulation near the attic vents.

7.2.13.4 *Knee Wall Ventilation*

1. Knee walls or attic spaces that are sealed from other attic spaces and outside of the thermal/pressure envelope may need to be ventilated as if they are separate attics.

7.2.13.5 *Attic Vent Area Guideline*

1. When attic ventilation is installed, use the following guideline:
   a. If the attic floor is outside of the thermal/pressure envelope, then 1 square foot of net-free ventilation may be installed for every 300 square feet of attic floor area.

7.3 Sidewall Insulation

Basement wall insulation, rim joist insulation and crawl space wall insulation are addressed under Section 7.4 on page 68.

7.3.1 Inspection, Preparation, and Repairs

1. Perform an inspection of the home from the interior and exterior prior to installing insulation. This inspection should identify all potential hazards and needed repairs.
    a. An inspection from the exterior of the home shall include an examination of the following:
        i. Building construction details.
        ii. Siding type and condition.
        iii. The location of electrical, gas, oil, and phone lines.
        iv. Plumbing pipes.
        v. Existing moisture and drainage problems.
        vi. Existing structural problems.
    b. An inspection from the interior of the home should include an examination of the following:
        i. Interior wall finish type and condition.
        ii. Electrical and plumbing utilities.
        iii. Duct work in wall cavities.
        iv. Dropped or suspended ceilings.
        v. Moisture problems.
    c. An inspection from the attic should include an examination of the following:
        i. Open top plates and balloon framing (attic flooring might have to be removed to adequately inspect for these bypasses).
        ii. Type of electrical wiring in the walls.
        iii. Knee wall areas.
        iv. Chimney and plumbing chases (attic flooring might have to be removed to adequately inspect for these bypasses).
    d. An inspection from the basement should include an examination of the following:
        i. Type of electrical wiring in the walls; in particular, knob-and-tube.

7.3.2 Moisture Inspection and Repair

1. Any leaks or other moisture problems must be repaired prior to the installation of wall insulation.

7.3.3 Treatment of Other Hazards

1. Use appropriate personal protective equipment and work practices in the presence of animal or insect hazards. Ensure personnel safety during work.
2. Remove any items that need to be moved in order to install wall insulation effectively.
3. Repair any rotted, broken, or damaged structural components. Ensure that the finished wall material will safely withstand the pressure of the insulation. Repair or replace any weakened, damaged, or missing interior wall surfaces so that they will withstand the pressure of the installation of the insulation. Use lead-safe work practices in all pre-1978 dwellings.
4. Set up ladders in a safe manner, using ladder levelers or other safety devices, to compensate for uneven ground or other physical impediments to safe ladder use.

7.3.4 Interior Inspection and Repairs

1. Repair or replace weak or damaged drywall or lath-and-plaster sections. In pre-1978 homes, repairs to these surfaces can generate lead paint dust and debris, so lead-safe work and clean-up practices must be employed of lead is found in the paint. Locate any areas of the interior wall surface that are weak or not securely fastened. Choose an insulation installation method that will not damage the interior wall surface. Repair or replace damaged or missing baseboard, casing, jambs, etc., that may allow insulation to escape from the wall cavity. Holes drilled for insulation must be plugged, finished, and returned to a condition as close to the original as possible.
2. Locate the positions of all wall-mounted switches and outlets before beginning insulation work. Locate all chases, utility runs, duct runs, wall heaters, vent fan penetrations, etc. prior to insulating. Block around these areas, if possible. If it is not possible to block around an area, avoid that area when insulating.

3. Find any interior soffit areas, pocket doors, or other structural details that may need preparation prior to insulating, and prepare as necessary. Locate critical framing junctures and ensure adequate insulation densities in these areas.

7.3.5 Exterior Inspection and Repairs

1. Note all types of siding material. Note siding material that may contain asbestos and/or lead-based paint. If the home is pre-1978, install a six-mil polyethylene ground cover at the bottom of the wall to catch chipping or flaking paint caused by the weatherization work. At the end of every workday, clean up all paint chips on the ground cover. Wherever possible, determine the presence and condition of old layers of siding or sub-siding.
2. Determine the best drilling strategy. The preferred method is to lift the siding or temporarily remove it before drilling the sheathing.
3. Repair or replace severely deteriorated window or door components. Replace all missing and broken glass.
4. Patch holes in exterior walls.
5. Determine the source of, and correct any problem that has led to, moisture in wall cavities prior to installing insulation. Repair or replace damaged, rotted, or deteriorated siding to ensure the integrity of the insulation. If any missing siding, flashing, etc. would allow disintegration of installed insulation, replace it with a comparable material.
6. Access structural additions and critical junctures to determine the ability of these areas to contain high-density insulation. Correct any openings or gaps prior to installing insulation.

7.3.6 Installation Methods for Wall Insulation

1. Wall areas above windows and doors (except in manufactured homes), and the area below windows must be insulated, whenever possible.
2. Uninsulated exterior walls without drywall, paneling, or other interior finish material must be insulated in the most cost-effective manner. If the estimated SIR for this application is less than 1.00 than the Deferral of Services Form shall be completed.
   a. If faced fiberglass batt insulation is installed, the vapor retarder must face indoors.

i. All vapor retarders must be covered with a 15-minute fire-rated material, such as ½-inch drywall or ¾-inch wood.
ii. If drywall is used to cover the insulation, it must be taped and mudded with one coat.
iii. Fiberglass insulation must not be left exposed.

b. If wet-spray cellulose is installed, a vapor barrier/retarder must be installed on the inside, but only after the wet-spray cellulose is properly cured.
i. All vapor retarders and cellulose must be covered with a 15-minute fire-rated material, such as ½-inch drywall or ¾-inch wood.
ii. If drywall is used to cover the insulation, it must be taped and mudded with one coat.

3. Enclosed walls must be dense packed whenever the interior wall surface material allows. Dense-packing requires:
a. An insulation machine with the proper capacity (at least 80 inches of water pressure at takeoff or 2.9 pounds per square inch of pressure).
b. The proper machine settings. For dense-packing, the air-to-material ratio must be high enough for a cellulose density of at least 3.25 pounds per cubic foot. On the other hand, if this ratio is too high, the job of insulating will take much longer. A balance must be found for each machine, delivery system, and wall.
c. Effective delivery of the insulation material from the machine to the end of the wall tube. This includes:
i. No air leaks in the hose or at the joints.
ii. A hose that is as short as possible for the job, but at least 50 feet.
iii. Gradual reductions or transitions in the delivery system to minimize clogging.
iv. A tube that is cut at an angle at the end to facilitate insertion into the wall cavity.
d. An operator that uses an effective technique, characterized by:
i. Inserting the tube all the way up to the top plate and then pulling down just less than 1 foot before the machine is turned on.
ii. Pulling the tube out of the fill hole by just less than 1 foot at a time as the flow of insulation in the hose and tube slows and

stops due to increasing resistance in the cavity. If the tube is pulled out too soon, the density will decrease.

iii. Inserting the tube downward through the fill hole after the wall cavity is filled upward from the fill hole. Inserting the tube with only the air running will help "drill" through the cellulose that has fallen from the upward fill. This will help achieve a higher density in the downward fill.

7.3.7 Blocking

1. Construction details that allow insulation to escape from sidewall cavities (such as balloon-framed walls) must be blocked or packed with fibrous insulation (such as fiberglass) or other material in a manner that effectively retains the insulation.

7.3.8 Insulating Floor Cavities between Exterior Wall Cavities

1. Open floor cavities between exterior wall cavities shall be insulated in balloon- and platform-framed buildings.
   a. Only those parts of these floor cavities that border the exterior must be insulated.
      i. In platform-framed buildings, these cavities must be accessed from the rim or band joists.
      ii. In balloon-framed buildings, these cavities are usually open to the walls, allowing access from the rim or band joists and also from the wall cavities above or below these floor cavities.
   b. The R-value of the insulation in these floor cavities must be at least equal to the R-value of the insulation installed in the adjacent wall cavities.
2. It is recommended that these cavities be insulated and blocked using the bag or bladder method. This method is probably the most cost effective when considering time and materials.[9]
   a. Joist cavities that are perpendicular to the band joists (usually on the eave sides of a dwelling) should be treated with the bag method.

[9] Woven plastic bags are available from NYP Corp., 805 East Grand Street, Elizabeth, NJ 07201, 800-524-1052. Seconds might be available. For normal floor cavity use, bag size should be at least 24 inches wide by 30 inches long. Used woven bags might be available from agricultural stores for a low cost.

b. Joist cavities that are parallel to the band joists (usually on the gable-end sides of a dwelling) should be completely filled with insulation from one end to the other.

7.3.9 Materials

1. For site-built dwellings:
   a. Insulate all closed-cavity sidewalls to 3.25 - 3.75 lbs./ft^3 with cellulose insulation. If it is not possible, document the reason in the client file.
   b. Insulate open cavity walls with:
      i. Cellulose insulation dense packed behind appropriate fabric netting fastened to the inside edge of the wall framing members.
      ii. Fiberglass (faced or unfaced) using a density and thickness appropriate for the cavity. Cover any flammable insulation facing or vapor barrier installed in an occupiable space with a fifteen-minute fire-rated material such as ½ inch drywall (taped at least once) or ¾ inch plywood.
      iii. Rigid plastic insulation may be used when appropriate. Cover any rigid insulation or vapor barrier installed in an occupiable space with a fifteen-minute fire-rated material such as ½ inch drywall (taped and mudded one coat) or ¾ inch plywood.
2. For manufactured home wall insulation materials, refer to Section 9.5 on page 86.

7.3.10 Insulation Coverage, Density, and Voids

1. Sidewall insulation must be installed according to the manufacturers' recommended density, and in a manner that does not allow the material to settle.
2. When insulating sidewalls with cellulose, install the insulation to a density of 3.25 - 3.75 lbs./ft^3 using the tubing method, unless there is good reason not to dense-pack. If the insulation is not installed to at least 3.25 lbs./ft^3, documented reasons must be included in the client file.
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. 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.
4. 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 6 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.

a. 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 six inches at the joints, and extend six inches up the basement wall 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

1. 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 on page 21.
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 zone pressure diagnostics 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 appropriate location of the pressure and thermal boundaries. Please refer to Section 14.9 on page 163 for instructions.
4. If the appropriate thermal/pressure boundary is determined to be the floor above the basement or crawl space (rather than the walls of the basement or crawl space), then this floor should be sealed, as necessary, before any insulation is installed under it. In these cases, the pre- and post-weatherization blower door tests shall be done with the basement door closed. These results should be documented on the appropriate field form, noting that the blower door test results exclude the basement and/or crawl space areas.

7.4.6 Storage Space

1. Where the basement or crawl space is being used for storage, agency personnel or the contractor should request the client remove the stored items from the weatherization work 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 or contractors should include the removal of items in the savings-to-investment analysis of installing insulation, and proceed with the measure if it is cost-effective (that is, if it has a savings-to-investment ratio of 1.00 or greater).

7.4.7 Materials

1. Interior basement wall insulation:
    a. If the wall is studded out on the interior, MaineHousing recommends a moisture and air impermeable insulation be used. Examples include double-faced, vinyl-backed fiberglass and extruded polystyrene.
    b. Double-faced, vinyl-backed fiberglass (metal building insulation) may be fastened at the band joist area and hung down 4 feet. It shall be mechanically fastened on all exposed edges with furring strips.
    c. Interior rigid insulation may be glued and fastened to the basement wall and shall be covered with an approved 15-minute fire-rated material, such as ½-inch drywall (taped and mudded one coat) or ¾-inch wood.
    d. Wet-spay cellulose insulation may not be used on basement or crawl space walls.
    e. Two-part closed-cell foam may be used and shall be covered with a 15 minute fire-rated material approved by the Maine State Fire Marshal's Office. Two-part foam shall be installed an average of 2 feet below grade.
2. Exterior basement wall insulation:
    a. Foundation panels (factory pre-finished on the exterior) may be used if they are glued and fastened, have drip caps installed, and are sealed around windows. They must extend at least 6 inches below finish grade.
    b. Extruded polystyrene that is not pre-finished may be used if it is glued and fastened, has drip caps installed, and is sealed around windows. The insulation must extend at least 6 inches below the finished grade.
        i. The exterior surface of these panels must be covered with a material that will protect it from ultraviolet light and physical damage.
        ii. If a masonry covering is used (stucco), a two-coat application is required to be installed over reinforced seams and a bonding agent.

7.4.8 Insulation Coverage

1. Insulation must be installed in a manner that provides as continuous a thermal boundary as possible.
2. Perimeter insulation must not be installed in a manner that excessively compresses the insulation material.

7.4.9 Rim or Band Joist Insulation

1. Installed insulation must be a minimum of R-10 unless a MaineHousing-approved energy audit calculation for the dwelling supports a different cost-effective level of insulation.
2. Band or rim joist area must be properly air sealed before the insulation is installed.
3. Fiberglass, rigid, or foam insulation may be used for this application and secured in a permanent manner. Whichever type is used, the installation must result in a savings-to-investment ratio of at least 1.0. Installed rigid or foam insulation must be covered with a 15-minute fire-rated material, such as ½-inch sheet rock or ¾-inch wood, as required.

7.4.10 Foundation Insulation, Additional Details

1. Route any exhaust fans to the outside using dampered vents, smooth bore rigid pipe, proper duct size for length of run, and an appropriate termination fixture.
2. If necessary, repair or replace exterior doors or door components to ensure tightness and to reduce air leakage. If necessary, replace all missing glass and repair or replace window components to ensure tightness and to reduce air leakage.
3. Foundation walls shall be insulated an average of 2 feet below grade; no section above grade should be left uninsulated.
4. Two-part closed-cell foam is recommended in basements that have uneven foundation wall surfaces, for example, rubble stone. Two-part spray foam is allowed under other foundation construction when used in conjunction with air sealing measures of the band/rim joist as long as it achieves the greatest SIR value. Installation of two-part foam must be found cost effective by the approved energy audit.
    a. Two-part closed-cell foam shall be covered with a 15 minute fire-rated material approved by the Maine State Fire Marshal’s Office.

b. When two-part spray urethane foam is used, follow EPA recommendations for the treatment of fumes. See Section 4.11 on page 27.

5. All appropriate fire code requirements must be followed when insulating basement walls.
6. Fiberglass insulation must not be left exposed to habitable areas. Double-faced, vinyl-backed fiberglass shall be mechanically fastened on all exposed edges with furring strips.
7. Mechanical fasteners must be used to secure perimeter insulation in a permanent manner.
8. Basement wall insulation must be a minimum of R-5 if installed on the exterior of the foundation, and R-10 if installed on the interior.

7.4.10.1 *Interior wall installation:*

1. A method for installing double-faced, vinyl-backed perimeter insulation is to attach it at the sill plate so that the blanket extends to 4 feet down the foundation wall. It should be run horizontally in a continuous manner to eliminate as many seams as possible. The bottom of this fiberglass batt insulation should be air sealed to the wall with a strip of wood and permanently fastened to the foundation.
2. Two-part closed-cell foam is recommended in basements that have uneven foundation wall surfaces, for example, rubble stone. Two-part spray foam is allowed under other foundation construction when used in conjunction with air sealing measures of the band/rim joist as long as it achieves the greatest SIR value. Installation of two-part foam must be found cost effective by the approved energy audit.
3. Stud out the walls and insulate with fiberglass or glue and fasten rigid insulation. The installation of a 15-minute thermal barrier shall be required as needed.
4. Other insulation types and methods may be used with the approval of MaineHousing.

7.4.10.2 *Exterior-wall installation:*

1. 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.

7.4.11 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 dampered vents, smoothbore rigid pipe, and an appropriate termination fixture.
5. Install perimeter insulation from the rim or band joists to the crawl space floor. 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.
6. An alternative method for installing interior perimeter insulation is to attach double-faced vinyl metal-building insulation (vinyl faced) at the floor above the rim. It should be run horizontally in a manner that minimizes the number of seams.. This insulation should 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 (make sure there is a ground moisture barrier in place first), whichever is appropriate.
   c. Mechanically fasten the insulation and seal all joints with tape.

7.5 Floor Insulation

7.5.1 Inspection, Preparation, and Repairs

1. 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 6 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

1. Please refer to Section 7.4.5 on page 69.

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 another

appropriate method. 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, is the preferred insulation material 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 11.1.5 on page 120 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 Sections 11.2.1 starting on page 122.
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

8.1 Primary Windows

8.1.1 Window Assessment

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

8.1.2 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

8.1.3 Window Air Leakage

1. 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.

8.1.4 Window Replacement

1. Window replacements must be based primarily on 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.

8.2 Storm Windows and Insulation Systems

8.2.1 Interior Storm Windows (ACPs)

1. Interior storm windows (ACP's) can be installed in whenever feasible and cost effective and 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.

8.2.2 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.

8.2.3 Non-Allowable Window Materials

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

8.3 Doors

8.3.1 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 air leaks.

2. All existing egress doors must remain operable.
3. Non-operable doors may be sealed against air leakage.

8.3.2 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.

8.3.3 Air Leaks in Doors

1. Air leak mitigation measures for doors such as jamb-up kits, sweeps, and thresholds must be determined to be cost-effective based on the approved MaineHousing energy audit.

8.3.4 Door Replacement

1. Individual replacement doors may only be installed if the cost of the repair is justified by a cost effective application of an SIR of greater than 1.0.
2. Pre-hung replacement doors may be installed if the installation is determined to be more cost-effective than:
   a. The repair of the existing door and frame, or the installation of a door that is not pre-hung.
   b. The cost of the purchase and installation of all hardware and the material associated with the replacement of a door must be included in the calculation of the SIR used to justify the door replacement.
3. Replacement doors may include one light (pane of glass) if the replaced door had one or more lights. The cost any other extra features must be borne by the client.

9 Manufactured Home Requirements

The same general procedures described in all other sections of these Standards shall apply to manufactured homes unless otherwise stated, or stated more specifically in this section.

9.1 Inspections, Preparation, and Repairs

1. The structure shall be properly supported, and if required restrained at the homeowner's expense before weatherization measures are installed.
2. Structural problems affecting insulation measures must be corrected prior to installing insulation.
3. Belly rodent barrier must be repaired if insulation will be installed, or if significant air leakage is occurring.

9.1.1 Moisture Problems

1. If there are moisture problems in the ceiling or sidewalls, insulation should not be added until the moisture source and/or site of penetration, including leaks, is identified and eliminated.
2. Exhaust-fan ducts terminating in ceiling cavities, crawl spaces, or other areas, shall be extended to the outdoors and sealed to prevent exhaust air from re-entering the conditioned space.
3. Whenever conditions warrant, install a moisture barrier on the ground in crawl spaces. This barrier should overlap at least 6 inches at the joints. Note: If the entire dirt floor is not accessible, cover as much as possible.
    a. 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.

9.1.2 Electrical Inspections

The electrical wiring in pre-1978 manufactured homes is sometimes aluminum. This aluminum wire, when in contact with other metals that are normally part of an electrical system, can cause galvanic corrosion and shorting. As a result of this possibility, in pre-1978 manufactured units special care should be taken.

1. Before insulating manufactured homes, inspect and assess the electrical wiring as follows:
   a. If the manufactured home has electrical wiring made of aluminum, a licensed electrician must inspect the home before any weatherization is started. After the weatherization work has been completed, the electrician must inspect the wiring again. Documentation of these inspections and their results must be in the client file.
2. Care must be taken to ensure that electrical wiring was not damaged during insulation work. The energy auditor should also determine if the electrical system is working properly before weatherization. This can be done by testing electrical outlets and switches before and after completing the work.

9.2 Air Leakage Reduction Requirements

1. Except for sealing ductwork and large holes to prevent insulation from entering the occupiable space, all insulation measures should be completed before additional air sealing work is done, whenever possible.
2. Air sealing activities should comply with the air sealing target procedure explained in Section 14.2 on page 146 of these Standards.
   a. The air sealing limit shall be the Air Sealing Target (AST), the Depressurization Tightness Limit (DTL), or 1000 CFM_{50} – whichever is highest. If the air sealing limit is below the DTL or 1000 CFM_{50}, only items under number 3 of this section may be completed.
3. Only the following air leakage reduction measures may be installed when the existing CFM_{50} measurement is below the DTL or 1000 CFM_{50}:
   a. Ductwork sealing.
   b. Insulation preparation work.
   c. Major repairs.
   d. Air sealing work that is necessary to block moisture migration into ceilings and walls.
4. Snap fasteners and/or weatherstripping shall be used whenever possible to reduce air and/or water leaks around primary windows.
5. Major air leaks around single-pane windows that cannot be eliminated with sidewall insulation or snap fasteners shall have an

interior storm window (ACPs) installed or the window replaced, whichever is most cost-effective.

6. Caulking is recommended around all interior casing when there is an interior storm window.
7. When accessible, the joint between the two sections of a double-wide must be filled and sealed at the top and bottom connections of the marriage wall.
8. Large holes in water heater closets with an exterior wall must be sealed, with care taken not to seal off combustion supply air from the outside.

9.3 General Insulation

Insulation shall be installed only in areas of the manufactured home envelope that separate conditioned from unconditioned space.

1. All wooden materials installed on the exterior of a unit that will be exposed to the weather must be pre-primed unless there are extenuating circumstances. Documentation justifying the use of unprimed materials must be included in the client file.

9.4 Ceiling Insulation

1. The ceiling and roof condition must be inspected and assessed before installing insulation.
2. If it is cost effective, ceilings that appear weak shall be repaired or reinforced – especially in heavy snow load areas – before installing insulation.
3. Recessed lighting fixtures and fan/light combinations that are Type IC rated by UL may be covered with insulation. Thermal insulation shall not be installed within 3 inches of fan/light fixtures or recessed light fixtures are not Type IC.
4. Ventilation fans may be covered with insulation if all holes and penetrations are sealed with a nonflammable sealant.
5. All combustible insulation materials shall be kept at least 2 inches from metal flues and chimneys with appropriate insulation dams.
6. Blocking around combustion appliance vents is required when insulation is installed, except where combustion air is pulled through a pipe that surrounds the combustion appliance vent pipe (concentric pipe system). Follow the manufacturer’s recommendation for clearances between vents and combustible insulation.

7. To prevent potential structural and or moisture issues, ceiling cavity insulation must be fiberglass and installed in a manner that ensures complete coverage over conditioned areas. Ceiling cavities should be blown to a density of 1.6 pounds per cubic foot (approximately R-4 per inch). It is useful to use a bag-count method to determine the total amount of insulation to install.
    a. If a double roof structure exists, fiberglass insulation shall be allowed in pitched roof cavities above the original roof, but only when this measure is cost effective.
8. If an interior drill-and-blow method is used for installing insulation, holes must be plugged and sealed properly. The holes must be straight and equidistant. In addition, there must be at least one access hole in each cavity to ensure complete coverage. In most manufactured homes, two access holes per cavity are preferred for a more even coverage.
9. If an exterior or side-opening (edge lift) installation method is used, all roof penetrations and areas of potential leakage must be sealed with elastomeric sealant (when compatible with roof materials) or another equivalent sealant, as necessary. Areas that are to be patched must be cleaned first, down to the metal roof surface. After insulation, reattach existing gutters with screws that are one size larger than the original screws. The edge-lift method is the preferred method to insulate manufactured home ceilings.
10. Installing insulation from the ridge of the roof is allowed.
11. If the roof requires a new coating after this insulation work, make sure the roof is strong enough to support workers. Temporary walking boards are recommended rather than walking on the roof itself.
12. If an end gable blow is utilized, steps must be taken to assure complete and adequate coverage is achieved. Attention to areas behind gussets, trusses, edges and corners is critical. Access to the gable end should be achieved by removing siding. Drilling and cutting vinyl siding is not an allowable method for access. If this method is used, the reasons for not using the methods listed in numbers 8 and 9 above must be documented in the client file.
13. Avoid cutting large holes and using screws on top of metal roofs, especially in heavy snow load areas.
14. In heavy snow load areas, educate the client whenever ceiling insulation is added, explaining that the depth of snow on the roof

could increase because of reduced heat loss. To minimize the possibility of creating leaks, educate clients on how to properly remove snow. Clients should be advised to refrain from walking on and or shoveling snow off the roof. Instead, they should use a roof rake or suitable tool from the ground.

9.5 Sidewall Insulation

9.5.1 Sidewall Insulation Requirements

1. Manufactured home sidewalls should be insulated when deemed cost-effective.
2. If the existing wall insulation thickness is less than the cavity depth, the apparent R-value must be reduced by at least 25 percent. The R-value may be decreased by more than 25 percent if the installation is of very poor quality and does not come in contact with all six sides of the cavity. If the R-value is reduced by more than 25 percent, the reason must be documented in the file.
3. The exterior siding and the interior wall materials must be inspected prior to the installation of insulation.
4. Weak or damaged wall materials must be repaired or reinforced prior to installing insulation. Pictures and other items hanging from the walls must be removed before installing the insulation.

9.5.2 Sidewall Insulation Methods

1. Vinyl faced fiberglass batt insulation (batt-stuff method) and loose fill fiberglass shall be used for manufactured home sidewalls. Select the method that will take the least amount of time to install. If it is important to install a vapor barrier or retarder, use the batt-stuff method with the vapor barrier installed on the warm side.
2. For cavities that cannot or should not be insulated with the batt-stuff technique, the fill-tube method with loose fill fiberglass shall be used.

9.6 Ductwork

9.6.1 General

1. Fiberglass (with the exception of duct board) shall not be left exposed on the inside of ductwork.

2. Visually inspect registers, boots, and the trunk where there is any evidence of air leakage or blockage.
3. Repair any missing, loose-fitting, disconnected, or blocked ductwork. Repair work is warranted if there is restriction or blockage of the duct that restricts air flow, even if there is no indication of air leakage.
4. Properly seal all detectable air leaks in duct system.
    a. Please refer to Section 11.1.1 on page 115 for duct sealing requirements and Section 14.7 on page 155 for pressure pan testing.
5. Inspect, test, and repair, if necessary, the connection between the furnace plenum and the main duct run.
6. Any portion of the ductwork that extends beyond the last register or grill may be sealed.
7. Trunk-end stops are only allowed if it is determined that the installation will reduce duct air leakage.
    a. End stops shall be made from sheet metal or aluminum valley flashing. Two-part foam may not be used unless it is adequately protected with a fifteen-minute fire-rated material. Any metal stops must be mechanically attached to the duct system. Gaps between the stop and the duct must be sealed with mastic.

9.6.2 Belly-Return Conversions

Belly-return air systems in manufactured homes are typically unhealthy for occupants and notoriously leaky. These leaky return systems can significantly increase the space heating costs and lead to thermal discomfort and indoor air quality problems.

Belly-return systems shall be converted to a living-space-return system if warranted by diagnostic testing. Follow the procedures below. When converting a belly-return system in a manufactured home to a living-space-return, follow the following procedures.

1. Replace the existing furnace closet door with a full louver door to ensure equal pressure between the furnace closet and the main area of the dwelling when the air handler is operating.
2. Block all floor return registers with a durable and tight air barrier, being careful to find hidden registers under built-ins, behind furniture, and in kitchen kick spaces.

3. Completely block all floor openings in the furnace closet using a fire retardant air barrier, being careful to not seal the combustion supply air inlet.
4. Check the temperature rise of the furnace to ensure that the airflow is not restricted. The temperature rise should be within the range specified on the manufacturer's label, or between 40^{o} and 80^{o}F. Refer to Section 14.6 on page 153 for more information.
5. Measure room-to-room pressure differences and relieve pressure differences that are greater than 3 Pascals.
   a. Close all interior doors. Measure the pressure difference across all interior doors. Pressure test and record measurements for all rooms with reference to the main body of the house.
   b. Take action if a room pressure difference exceeds 3 Pascals. Relieve pressure by:
      i. Opening the door slightly while measuring the pressure difference across the door. Open the door until the pressure difference is 3 Pascals or less and measure the square inches of opening. This is the size of the opening that must be created in the door by:
         1. Undercutting the door; or
         2. Installing a direct grille, offset grilles, or jumper duct to relieve the pressure imbalance caused by the distribution system when the door is closed.
6. After all steps have been completed for converting a belly return distribution system to a living-space-return system, make sure the furnace and distribution system are working properly.

9.6.3 Crossover Duct Repair and Treatment

1. Crossover ducts shall be installed in a manner that prevents compression or sharp bends, minimizes stress at connections, avoids standing water, and avoids long runs. When there is no skirting, the crossover duct shall be protected against rodents, pets, etc., and properly suspended at intervals of four feet or less above the ground. If replacement is needed, replace with rigid duct and insulate to R-8.
2. Flexible crossover ducts shall have a minimum R-8 insulation. They shall be secured with mechanical fasteners (for example, stainless steel worm drive clamps, plastic/nylon straps applied with a tightening tool, etc.) and sealed with mastic or aluminum foil-backed butyl or a comparable pressure-sensitive tape.

3. Existing flexible crossover duct with an insulation R-value of 4 or less and which has been damaged shall be replaced with new rigid duct with R-8 insulation.
4. The crossover must be replaced if the inner lining is brittle or made of mesh. If in doubt, replace it. In many cases, a leaky crossover can be repaired by cutting out the section of duct containing the leak. A fabricated sheet metal sleeve can be inserted between the remaining pieces of crossover duct. The metal sleeve must be attached to the flex duct crossover using ratcheting plastic straps.
5. Crossover ductwork must be appropriately secured above the ground. It may be supported by strapping or blocking.
6. Flexible duct shall not be allowed to sag more than 12 inches over a span of 8 feet.

9.7 Floor (Belly) Insulation

9.7.1 Floor Insulation Requirements

1. Belly insulation shall be installed only after all repairs have been made, major holes in the belly rodent barrier and floor have been sealed, and all ductwork has been sealed according to Section 11.1.1 on page 115.
2. Belly rodent barriers must be inspected for general condition, structural strength, and major air leaks prior to installing insulation.
3. Make necessary belly rodent barrier repairs if additional insulation will be added, or if holes in the belly allow significant air movement between the belly cavity and the outside atmosphere.
4. Belly cavities must be inspected to determine the location of the plumbing, any plumbing leaks, and the R-value of existing insulation. Leaks should be fixed prior to weatherization. If water pipes are located at the bottom of the belly rodent barrier and it is not possible to get at least 2 inches of insulation between the pipes and the belly rodent barrier, then the following measure must be attempted, if it is cost effective:
   a. The pipes must either be insulated with additional insulation, either inside the belly or on the exterior of the rodent barrier; or
   b. The pipes shall be moved closer to the floor above, or
   c. The insulation above the pipes should be removed.

   d. If none of the above measures can be taken, then the belly shall be insulated using the perimeter method.
5. Belly insulation must be installed in a manner that ensures complete coverage of all heated areas. If the floor insulation system is beyond cost effective repair or replacement, an insulated skirting system may be considered if deemed cost effective. In these cases, consult MaineHousing.
6. Holes that have been made in belly rodent barriers for the installation of insulation must be patched and sealed. One section of a three-tabbed shingle may be put into the cavity at the tube access point before insulating, and then moved into place to cover the slit in the belly after the insulation is installed.
7. Rim joists may not be drilled if they are determined to be a structural component of the foundation support system.
8. Average insulation densities for loose fill fiberglass insulation installed in manufactured home bellies shall be – 1.25 to 1.75 lbs./ft^3
9. Bellies shall not be dense packed or over-filled so as to create undue stress on the belly rodent barrier.

9.7.2 Floor Insulation Methods

1. Fiberglass shall be the insulation material for manufactured home bellies.
2. Bellies that hang up to 8 inches or less below the floor in the center area should be filled entirely with insulation blown at the required densities.
3. Bellies that are greater than 8 inches below the floor at the center area should be insulated using the perimeter method. If possible, leave space between water pipes and the floor to reduce the likelihood of frozen pipes.
4. Determine if the manufactured home has a hanging belly (floor joists run from one side of the dwelling to the other) or flat belly (floor joists run the length of the dwelling).The preferred method for insulating bellies is from the edge.
   a. When insulating a hanging belly (floor joists run from one side of the dwelling to the other), a 2 ½- or 2 9/16-inch hole should be drilled in each cavity. A rigid pipe or tube should be inserted to the opposite wing. The wings should be dense packed with fiberglass

(1.6 pounds per cubic foot) and the center should be loose-filled (not dense packed).

b. When insulating a flat belly (floor joists run the length of the dwelling), appropriately sized holes should be drilled in each end cavity and dense packed with fiberglass to 1.6 pounds per cubic foot. The center sections must be completed from under the belly.

5. Belly patches shall be installed in a permanent manner using lath strips and non-corrosive screws when possible, adhesives, and outward clinch staples.
6. Insulated sheathing board, fiberboard, and nylon-reinforced belly-bottom material specifically manufactured for manufactured homes are the preferred patching materials for belly patches. Material installed shall be designed for use in the cold climate of Maine. Soft patching materials that may be used include Tyvek and Typar. Patches should be adhered with silicon or other durable caulk and then stapled with clinch staples.
7. Upon completing insulation work:
   a. Rim joists that have been drilled shall be plugged with an appropriate plug. The plug shall be sealed in the hole with an adhesive compound.
   b. Ductwork shall be inspected for insulation that might have accidentally gotten inside the ductwork during insulation work.
8. The furnace shall be cycled to ensure proper operation.
9. Incidental repairs to existing skirting are allowed.

9.8 Insulation of Water Supply Systems

1. To prevent freezing;
   a. Water pipes that have not been covered by under-floor insulation should be insulated to a minimum of R-3.
   b. Box the individual water supply system pressure tank with 2 inch extruded polystyrene insulation. Make sure the outer surface of this insulation is protected from direct sunlight.
   c. In certain situations it may be more cost effective to insulate the skirting.
2. The piping shall be free from water leaks and properly secured to support the weight of the piping and insulation.
3. The insulation product may either be flat and capable of being molded to the outside of the pipes, or preformed to fit standard pipe

diameters. If the product is preformed, dimensions shall be appropriate for the pipe size.

4. If the insulation is exposed to the weather, it shall be resistant to degradation from moisture, ultraviolet light, and extremes in temperature, or a jacket or facing shall be installed that protects the insulation from these conditions.

9.9 Water Heater Closets

1. At a minimum, water heater closets with an exterior wall must be treated as follows:
   a. The exterior access door and adjacent exterior walls of closets containing electric or gas water heaters shall be insulated. If this cannot be done, the reason must be documented in the client file. If the door and adjacent wall can be insulated, the water heater shall not be wrapped with insulation.
      i. Cover any air vents in the door or adjacent exterior wall.
      ii. Bring combustion air from underneath the belly or through the skirting by installing an appropriately sized metal chute with a rodent barrier.
   b. If it is not possible to insulate the exterior closet door and adjacent exterior wall area:
      i. The tank should be wrapped with an insulation blanket. Please refer to Section 12.1.4 on page 126 for instructions.
      ii. Large holes in the closet walls that allow air leakage into the interior must be sealed.
      iii. All plumbing within the closet that is susceptible to freezing must be insulated.
      iv. An adequate amount of combustion air must be provided to gas water heaters according to NFPA 54 requirements.

9.10 Combustion Systems

1. All fuel-burning, heat-producing appliances in manufactured homes, except ranges and ovens, must be vented to outside. Further, all fuel-burning appliances in manufactured homes, except ranges, ovens, illuminating appliances, clothes dryers, existing solid fuel-burning fireplaces and existing solid fuel-burning fireplace stoves, must be installed to provide for the complete separation of the combustion

system from the interior atmosphere of the manufactured home (i.e., to draw their combustion air from outdoors).

2. If interior combustion air is used for the furnace, replacement with a sealed combustion (direct-vent) furnace is mandatory for weatherization to proceed or postponement of services is required.
3. For replacement of solid-fuel burning appliances, please refer to Section 10.6.1 on page 112.

9.11 Inside Storm Window Installation (ACP)

1. The installation must be deemed cost effective.
2. Panels must be removable and numbered. The client must be educated regarding their removal, storage, and reinstallation. This measure should not be done unless the energy auditor is assured by the client that they will maintain and reinstall panels correctly.
3. Self-storing insider storm windows may also be considered if justified by the MaineHousing energy audit.

9.12 Baseload Electricity Reduction

Electric baseload measures, as described in Section 12 on page 124, are to be considered for manufactured homes, including refrigerator replacements, compact fluorescent light bulbs, and low-flow showerheads.

10 Combustion Appliances

The efficient operation of heating systems is a critical aspect of the efficient use of fuel. Replacing heating systems or major components of heating systems is allowed to resolve health and safety concerns if the appliance is operable at the time of initial assessment. Minor repairs that will result in an operable appliance are allowed. Repairs and adjustments to heating systems and their controls must be done by a fully licensed technician. Energy auditors with the Limited Energy Auditor Technician license may perform combustion safety testing and steady-state efficiency testing (refer to Section 2.2 on page 7).

10.1 Combustion Appliance Work Documentation

1. Each client file must include documentation of any and all efficiency work and adjustments made to the water heating and space heating combustion appliances.
2. Client file documentation must include information on the applicable combustion appliance efficiency tests (see Section 10.3.5 on page 105) and components (see Section 10.3 on page 97).
3. Before the work on a combustion appliance is complete, a representative of the agency must have finished a review of all combustion appliance forms and determined that the combustion

appliance(s) meets the specifications in Chapter 3 starting on page 9 and Section 10.3 on page 97.

10.2 Combustion Efficiency and Analysis

Acceptable combustion analysis values are found in Table 10-1

1. The steady-state efficiency of a central heating system should be checked to determine:
   a. If the heating system needs cleaning and tuning.
   b. If the heating system functions as efficiently as it was designed to. Refer to Section 10.3.5 on page 105 for steady-state efficiency testing instructions.
2. Replace the heating system if the approved energy audit determines that it is cost-effective to do so.

Table 10-1

Acceptable Combustion Test Analysis Values				
Heating Unit Type	***Oxygen (O_2)***	***Carbon Dioxide (CO_2)***	***Net Stack Temp.***	***Smoke Test***
Gas				
Atmospheric	4 - 9%	Natural 9.6 - 6.8% LPG 11.2 - 7.8%	300-600º F	NA
Fan-assisted	4 - 9%	Natural 9.6 - 6.8% LPG 11.2 - 7.8%	300-480º F	NA
Condensing	See man. Info.	See man. Info.	See man. Info.	NA
Standard Power Burner	4 - 9%	Natural 9.6 - 6.8% LPG 11.2 - 7.8%	300-650º F	NA
Oil (No. 1 & 2)				
Oil gun burner	4 - 9%	12.5 - 8.8%	325-600º F	1 or less
Flame Retention	4 - 7%	12.5 - 10.3%	325-600º	1 or less

burner			F	

10.3 Space Heating System Requirements

Health and safety requirements for space heating systems are required. Please refer to Section 4.17 on page 39 for details.

10.3.1 Forced Air Systems

An efficiency safety check should be conducted by a qualified technician 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[10]. 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 and just above a natural gas line. If a leak is detected, verify with soap solution. All identified gas leaks should be referred to licensed technicians for repair or replacement.
    b. *Flexible gas lines* must be replaced when:
        i. The line is badly kinked, corroded or shows signs of physical wear;
        ii. The line connection is the soldered, two-piece type; or
        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 criteria just above.
    c. *Cleaning and tuning:* All gas-fired units should be cleaned and tuned once every 2 to 3 years. Suggest the client have this service performed regularly.

1. Oil-fired unit requirements:
    a. *Oil storage and piping:* Check the oil tank and piping for leaks and compliance with all appropriate codes.

[10] A smoke test result greater than 2 indicates the oil-fired combustion appliance is in need of cleaning and tuning. If this is the case, a cleaning and tuning should be ordered, rather than continuing with a steady-state combustion efficiency test.

b. *Cleaning and tuning:* All oil-fired units should be cleaned and tuned annually. Make sure the client is having this service performed regularly.

2. *Thermostat:* The heating system 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 the 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.
3. *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 temperature and 130^{o}F, but never to exceed 140^{o}F.
4. *Limit switch:* This switch should shut the burner off at approximately 200^{o}F, where appropriate.
5. *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 14.6 on page 153 for instructions on measuring temperature rise.
6. *External Static Pressure (ESP) test:* Must be checked on all furnaces. The ESP should fall within the manufacturer's recommended ESP range (see name plate on appliance). See Section 14.5 on page 152 for instructions on measuring ETP.
7. *Blower belts and pulleys:*
   a. Cracked or broken blower belts shall be replaced.
   b. If a larger pulley is installed on a belt drive furnace blower, the motor amperage must be measured. If the amperage draw is more than the motor's rated amperage, a smaller pulley must be installed, and the motor amperage measured again.

[11] 40 CFR 271.13

8. *Draft/Spillage:* All heating systems must be properly vented. All non-sealed combustion systems must be tested with a draft-testing device and must meet the acceptable draft requirements. There must be no spillage two minutes after firing. The flue must not be clogged, disconnected, or rusted to the point where it leaks. All systems, with the exception of direct-vent units, must be tested with worst-case depressurization test procedures (see Section 14.7 on page 155).
9. *Ductwork:* Return ductwork located in the combustion appliance zone (CAZ) shall be sealed if such sealing prevents hazardous negative pressure in the CAZ during air handler operation. Please refer to worst-case depressurization testing procedures in Section 14.7 on page 155. Please refer to Section 11.1.1 on page 115 for details of duct testing and repair.
10. *Filter*: A clean furnace filter should be installed in a location where the client can locate it for the purpose of replacing or cleaning it.
11. *Blower or air handler:* The air handler/blower should be visually inspected to determine if it requires cleaning. If necessary, it should be cleaned. The motor and blower must be oiled (where applicable).
12. *Central air conditioning coils* should be accessed and cleaned whenever airflow is excessively restricted by dirt on the coil.
13. Unused or non-functional central air conditioning coils should be removed to increase airflow.
14. *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.

10.3.2 Gravity, Space, Wall, and Floor Furnaces

All gravity, space, wall, and floor furnaces should conform to the following standards:

1. *Gas-fired unit requirements:*
    a. *Gas Leaks:* When testing for gas leaks, hold the leak detector probe just below a propane gas line and just above a natural gas line. If a leak is detected, verify with soap solution. All identified gas leaks should be 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. Make sure the client is 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. Make sure the client is 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 or replacement shall be removed, replaced and disposed of in accordance with EPA regulations[12]. 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.
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. *Draft/Spillage:* All furnaces must be properly vented. All non-sealed combustion furnaces must be tested with a draft-testing device and must meet the acceptable draft requirements. There must be no spillage two minutes after firing. The flue must not be clogged, disconnected, or rusted to the point where it leaks. All furnaces, with

[12] 40 CFR 271.13

the exception of direct-vent units, must be tested with worst-case depressurization test procedures (see Section 14.7 on page 155).

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 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. Make sure the client is 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. Make sure the client is 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 regulations13. 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.
4. It is preferred that manufactured home thermostats be located on an interior wall.
5. *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.
6. *Limit switch:* This switch should shut the gas valve off at approximately 200^{o}F, where appropriate.
7. *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.

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The furnace must not cycle on the high-limit switch. See Section 14.6 on page 153 for instructions on measuring temperature rise.

8. *Ductwork:* For a discussion of duct leakage measurements and standards, follow the instructions in Section 11.1.3 on page 118. For ductwork sealing and insulation, follow the instructions in Section 11.1 on page 115.
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 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 should be cleaned and tuned once every 2 to 3 years. Suggest the client has 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. Make sure the client is having this service performed regularly.

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

4. *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[14]. 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.

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

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

[14] 40 CFR 271.13

7. *Draft/Spillage:* All boilers must be properly vented. All non-sealed combustion boilers must be tested with a draft-testing device and meet the acceptable draft requirements. There must be no spillage two minutes after firing. 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 14.7 on page 155).
8. *Circulator(s) on hot water boilers:* The motor must be checked for proper operation and oiled (where applicable).
9. *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.
10. *Other cleaning:* Other necessary cleaning should be done, including air intakes, burners, furnace controls, and heat exchangers.
11. *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.

10.3.5 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. Locate an existing hole, or drill an appropriately-sized hole for measuring the draft.
   iii. 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.
   iv. With a combustion analyzer, measure the oxygen (O_2) 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.
   vii. Proceed to measuring the draft.

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.

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.

i. Inspect unit for hazardous conditions.
ii. Locate an existing hole or drill and appropriately-sized hole for measuring the breech draft. This hole is also used for measuring the smoke, the oxygen percentage, and the temperature.
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.
vii. Proceed to measuring the draft.

2. *Draft measurement:*
   a. *Gas systems:* The proper draft hole test location is 2 feet downstream from the draft hood or draft diverter in a straight section of the flue pipe; or, if the 2-foot measurement falls on an elbow, in the first straight section of flue pipe beyond 2 feet. Acceptable draft values for atmospheric gas systems are listed in Table 10-2.

Table 10-2

Atmospheric Gas Appliances Only (Category I, natural draft) Acceptable Draft Test Readings for Various Outdoor Temperature Ranges					
ºF	<20	21-40	41-60	61-80	>80
Pascals	-5	-4	-3	-2	-1
Water Column inches	-.02	-.016	-.012	-.008	-.004

b. Oil systems, low-static pressure burners:

i. Overfire draft: This draft reading is taken just above the oil burner through an opening into the firing chamber, if present. The overfire draft reading should be -2.5 to -5 Pascals or -0.01 to -0.02 inches of water column. It should not be less.

ii. Flue pipe or breech draft: This draft reading should be taken through an appropriately sized hole – usually ¼-inch or slightly larger – drilled about 12 inches from the heating unit and at least 6 inches before the barometric damper (draft regulator). This draft reading should be from -10 to -15 Pascals (-0.04 to -0.06 inches water column).

iii. Acceptable draft values for low static pressure, oil-fired systems are listed in Table 10-3.

Table 10-3

Power Oil Burners, Low-Static Pressure Acceptable Draft Readings Overfire and at Breech	
Draft Reading Location	**Acceptable Draft**
Overfire Draft	-0.01 to -0.02 inches or -2.5 to -5 Pascals
Vent Connector or Breech	-0.04 to -0.06 inches or -10 to -15 Pascals

c. Oil systems, high-static pressure burners:

i. The vent connectors of high-static pressure oil burners with positive pressure in the vent connector should not be drilled for testing, except by a fully licensed oil burner service person.

3. Measurement of External Static Pressure (ESP):

a. Refer to Section 14.5 on page 152.

4. Measurement of temperature rise:

a. Refer to Section 14.6 on page 153.

5. *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.

6. *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

1. 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.

1. 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.
   a. Oil-Fired Boilers, 83% AFUE.
   b. Gas-Fired Boilers, 83% AFUE.
   c. Oil Furnaces, 83% AFUE.
   d. 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[15] 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. 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:

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

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.

iii. If any secondary unvented heater is left in the dwelling after weatherization, a Deferral of Services Form must be completed and put in the client file. Client education must be provided on the limited use of the unvented space heater.

2. Any space heater replacement or repair procedure should include inspection to ensure that working smoke and carbon monoxide detectors are installed on the same floor as the space heater. In instances where smoke and carbon monoxide detectors are not present or are not operating properly, new detectors may be installed with DOE funds. The purchase and installation cost of the smoke and carbon monoxide detectors may be charged to the health and safety category or to program operations at the State's discretion.
3. DOE policy does not allow fuel switching except on a limited case-by-case basis. An exception to this rule is with unvented kerosene heaters, where fuel switching is allowed when practical. Specific replacement and fuel types are discussed below.
4. Electric space heaters: DOE does not allow WAP-funded work on electric space heaters other than incidental repairs.
5. When an unvented space heater is replaced, the old heater must be removed from the dwelling.

10.6 Solid-Fuel Heating Appliances

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.

If an installation does not maintain the minimum recommended clearances (see below and NFPA 211) from all unprotected combustible walls, ceilings, or floors, then remedy these deficiencies before weatherization proceeds. The client shall be notified of any unsafe conditions.

If an installation contains a chimney connector of less than 22-gauge metal, contains a creosote buildup of ¼ inch or more, does not have a smoke and carbon monoxide alarm, remedy these deficiencies before weatherization proceeds.

1. No wood stove may be exhausted into an unlined masonry chimney. Chimney work is an allowable expense, however, if needed chimney work is not addressable with existing program funds, such wood stove configurations shall be disconnected and the chimney penetration sealed before other weatherization work can proceed.
2. The following NFPA 211 requirements must be used for all solid-fuel heating system installations.
    a. Triple-wall or insulated double-wall vent connector pipe must be used within 2 inches of combustible materials.
    b. Double-wall vent connector pipe must be used within 18 inches of combustibles and must be kept at least 9 inches from combustibles.
    c. Single-wall vent connector pipe must be kept at least 18 inches from combustibles.
    d. If necessary, provide combustion air from outdoors to reduce negative pressure around solid-fuel appliances.
    e. Single-wall solid-fuel appliances must be kept at least 36 inches from combustibles.
    f. Stoves installed closer than 36 inches to combustibles must be double-wall, or combustibles must be protected by ventilated, non-combustible wall protectors.
    g. Stove clearances of less than 36 inches must be specified by the manufacturer and printed on a metal tag attached to the stove.
    h. For further information, refer to NFPA 211.
3. Wall and floor heat protection requirements.

a. Wall and ceiling protection must be at least 26-gauge (0.013 inch) sheet metal with 1-inch spacers or other approved material.
b. Floor protection must be:
    i. If there is at least 18 inches of open air space between the bottom of the solid-fuel appliance and the floor, use at least 24-gauge (0.024 inch) sheet metal.
    ii. If there is between 6 and 18 inches of open air space between the bottom of the solid-fuel appliance and the floor, the floor protection material should be ¼-inch cement board covered with 24-gauge sheet metal.
    iii. If there is less than 6 inches of open air space between the bottom of the solid-fuel appliance and the floor, the floor should be protected with 4-inch thick masonry blocks arranged with the holes interconnecting and open to allow free air circulation through the floor protector. The hollow masonry should be covered with 24-gauge sheet metal.

4. Replacement vent connectors shall be single- or double-walled stovepipe of at least 22 gauge. Each joint must be secured with at least three sheet metal screws or equivalent fasteners with joints facing in the proper direction. Vent connector material installed in the living space of a dwelling unit must be either black or stainless steel. Galvanized vent connector shall not be used in a living space because it emits toxic zinc vapors when heated.
5. Chimneys should be mechanically cleaned using a wire brush and rods manufactured for this purpose. Any stiff wire brush may be used to clean vent connector material. Chemical chimney cleaning products are not an allowable expense in the Maine Weatherization Program.

10.6.1 Solid-Fuel Appliance Replacement Policy

Solid-fuel appliances are defined as those that burn wood (cord or pellet) and coal. Solid-fuel appliances include heating stoves, ducted gravity furnaces, and forced air furnaces. The venting and clearances of existing installations must be made, when reasonably possible, to comply with the current edition of NFPA 211. Repairs are preferred to replacements. See Section 4.2 (6) page 16 for more information.

1. Replacement of a solid fuel appliance is allowed only when there is a crack in the heat exchanger that can cause a carbon monoxide

problem or a fire hazard. All replacements must comply with the current NFPA 211.

2. There may be situations where the costs of a new installation or the repair of an existing installation may be too expensive for the Maine Weatherization Program to incur.
   a. In some cases, the owner may have to be responsible for some or all of the costs for making a solid fuel appliance installation safe.
   b. In situations where an owner is responsible for making any health and safety repairs; a Deferral of Services Form must be completed with an addendum describing each problem to be corrected. A copy must be left with the owner and a copy becomes a part of the client file.
3. Cost of repair and replacement of solid fuel appliances are to be charged to health and safety.
4. Replacement of solid-fuel gravity furnaces, forced air furnaces, and boilers will not be permitted and are considered beyond the scope of weatherization. However, repair of existing units will be permitted.
5. Solid-fuel appliances in manufactured homes:
   a. Replacement of solid-fuel appliances in manufactured homes must be manufactured-home approved direct-vent stoves. Manufactured-home, solid-fuel stoves and approved venting systems are expensive. The material costs for these measures can easily exceed the targeted 15 percent of the total material cost for the job allotted for health and safety, so careful consideration must be given to the replacement of solid-fuel appliances in manufactured homes.

10.6.2 All Other Heating Systems

1. The MaineHousing must be consulted before beginning work on heating systems other than those specifically addressed in these standards.

10.7 Central Air Conditioning in Manufactured Homes

1. In some cases, when manufactured homes have central air conditioning added to the furnace ductwork, an air-pressure controlled damper is installed (sometimes just under the furnace) to regulate the flow of heated or cooled air. Occasionally this damper

will stick, thereby preventing the free flow of heated or cooled air. If this happens in a client's dwelling, money may be expended to repair this cooling/heating damper.

11 Heating System Distribution

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 14.7 on page 155).

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.

11.1.1.1 *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 14.7 on page 155
   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, signification 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.

11.1.1.2 *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 on page 87).
2. For a living-space-return system, the preferred duct leakage rate is zero (the sum of the pressure pan readings) while a blower door is depressurizing the dwelling to negative 50 Pascals.
3. For a living-space-return system, a total of one Pascal per register for the pressure pan readings is acceptable if:
   a. The floor boots are sealed with mastic, fiber tape, and/or sheet metal, as necessary;
   b. The end of the supply trunk ducts are sealed;
   c. Any crossover ducts are visually inspected, repaired and sealed, as necessary (refer to Section 9.6.3 on page 88); and
   d. The furnace plenum is sealed with mastic, fiber tape, and metal, as necessary.
   e. Goal: Attempt to reduce the sum of the pressure pan readings to between zero and 3 Pascals.
4. If difficulty is experienced meeting the goals, use a “pillow” (fiberglass insulation inside of a plastic bag) to block and segment sections of the ducted system to assist in finding leaks.

11.1.2 Ductwork Inspection, and Cleaning, and Sealing

1. Delivery and return ductwork must be cleaned as necessary to remove large objects and debris that may impede airflow through the heating system.
2. Uncover any blocked registers or grilles. Explain to the client the importance of maintaining the unrestricted airflow.

3. As necessary, delivery and return air grilles and registers must be removed and cleaned to remove excessive dirt and debris that may impede airflow.
4. When appropriate, remove and block off ducts, registers, and grilles located in unconditioned spaces.
5. Ductwork outside the thermal envelope of the dwelling must be sealed with mastic and insulated to at least R-8 (preferably R-11, when possible).
6. All accessible return air ductwork within a combustion appliance zone (CAZ), except gravity systems, must be sealed enough to eliminate the potential for backdrafting. Please refer to Section 14.7 on page 155 for Worst-Case Depressurization Testing procedures.
7. Ducts and registers into non-living areas of the structure may be sealed off with the owner's permission.
8. Existing crawl space plenums should be abandoned and replaced with a sealed duct system.

11.1.3 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 roofing nails or staples. Wood screws may also be used. Ensure that the heads of the screws 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.

11.1.4 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 11.1.3 on page 118, number 2.c.).
3. Mastic shall meet the following requirements:
   b. Non-toxic and water-resistant.
   c. UL listed and labeled per UL 181A or 181B standards.
   d. 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.

11.1.5 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 11.1.3.
   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.

11.1.6 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 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 14.7 on page 155 for details). This includes testing for proper draft during worst-case depressurization.
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 100 ppm as-measured or 200 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. 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:
    e. The temperature and pressure relief valve on an electric unit.
    f. The drain valve on an electric unit.
    g. Where the electrical line attaches to an electric unit. Insulation must be keep at least two inches away from where this electrical line attaches to the water heater.

12.1.5 Domestic Hot Water Temperature

1. Whenever feasible, the domestic hot water temperature must be measured. 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.

12.1.6 Energy-Saving Showerheads

1. An energy-saving (low-flow) showerheads 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

1. 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 model refrigerator if the applicant agrees to have both the existing units removed.
2. 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.
3. All refrigerators considered for replacement shall be metered with a MaineHousing approved source, unless there is reliable evidence that the refrigerator was manufactured in 1995 or earlier. If the refrigerator was manufactured in 1995 or later, it may still be metered, but it is not required.
4. 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 based on actual metering of the refrigerator with an approved MaineHousing method.

b. Identify the make and model number of the refrigerator. Find the brand, model, and annual electrical consumption in a reliable AHAM listing of refrigerators. If appropriate, multiply the annual kWh/yr. consumption estimate listed by the degradation multiplier listed in Table 12-1.

Table 12-1

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

5. 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 Metering and Replacement of Refrigerators

1. Auditors will:
   a. Explain the metering process.
   b. Ask the client how many refrigerators and freezers are being used in the dwelling, and for what purposes.
   c. Ask the client to make all refrigerators and freezers in the dwelling available for metering (clean off top) and make sure the contents are secure in the event that the auditor must move the unit.
   d. if there are any known refrigerator/freezer malfunctions.
2. The meter will be connected to the refrigerator(s) for at least two hours.
   a. Plan the energy analysis, entry interview, and overall visit so that the metering equipment can be connected promptly. Leave the meter device in place for a minimum of two hours. The longer the metering time, the more accurate the projected annual kWh/yr. estimate will be.
3. Follow the manufacturer’s instructions for the use of the meter.
4. Listen for the refrigerator/freezer compressor before you unplug the electrical cord to attach your meter (a typical refrigerator compressor runs 25 – 50 percent of the time). If you must unplug the compressor while it is operating in order to connect your meter, wait about 5

minutes before plugging it back in to avoid tripping the compressor safety switch (or, go ahead and "test" the restart protection, assuming that if the switch is ready to fail, the unit is a candidate for replacement).

5. Be careful with the electrical connections and outlets into which the refrigerator is plugged. Check the outlet you use with an analyzer. If the outlet does not meet the criteria below, try to find a better one close by and use your extension cord. If no available outlets meet the necessary criteria, use the best outlet available:
   a. The outlet should be secure in the wall.
   b. The outlet should be properly grounded.
6. Complete the installation of the metering device.
7. If it is necessary to move the refrigerator/freezer to attach the meter, be careful of the floor material. Carry a sturdy rug to help slide the unit in and out without damage to the floor (a piece of 2 x 4, 4 feet long is often useful as a lever for lifting and moving). Make sure the contents inside and on top of the refrigerator are secure before moving it. If the unit cannot be moved or would potentially cause damage to the floor, document the reason why no metering was done and move on to other audit procedures (in such a case, you must apply for a waiver request).
8. Open the refrigerator/freezer door(s) in order to:
   a. Place your high/low recording remote-bulb thermometer properly, if necessary.
      i. If you can find and safely manipulate the defrost-cycle timer to a position just beyond the defrost cycle, do so to eliminate the possibility of the refrigerator going into the defrost cycle during your metering time.

      Note: This step is not necessary for manual defrost refrigerators. Additionally, some meters measure peak Wattage during metering; this can be a reliable indication of whether the defrost cycle activated during metering (see manufacturer's instructions).

      ii. After the freezer door is closed, allow the remote bulb and thermometer to reach a steady-state temperature, and then reset the high/low thermometer. This will require from three to five minutes. The remote bulb in the freezer will indicate whether or not the refrigerator goes into defrost cycle during your metering. A normal freezer temperature is 5 to 20^{o}F.

During the defrost cycle, the temperature in the freezer can reach as high as 60°F. During the metering time, periodically check the real-time freezer compartment temperature on the thermometer for above-freezing temperatures, and always check the recorded high remote temperature at the end of the metering time. If the remote bulb temperature has registered a temperature greater than 40°F, make sure the automatic defrost refrigerator has gone into the defrost cycle during your test period. If so, you must abort the test and start over when the defrost cycle finishes.

Note: This step is not necessary for manual defrost refrigerators.

iii. Place the main body of the thermometer outside of the refrigerator compartment on a counter or other place where it will be convenient for you to see the remote bulb during your metering. This thermometer is used to determine the Present Ambient Temperature (PAT). Determine and record the control setting in the fresh-food compartment of refrigerators.

b. Determine and record the control setting in the freezer compartment.

c. Determine if the unit has an anti-sweat feature; if so, make sure it is switched off.

d. Close the door(s) as quickly as possible.

9. Check the initial instantaneous kilowatt reading on your meter just after you connect it. Here are some Watt consumption ranges that will give you a hint of where the refrigerator is in its cooling/defrost cycle:

   a. 0.010 - 0.040 kilowatts if the door is open (and the light bulb is on), and/or anti-sweat heaters are on.

   b. 0.250 - 0.400 kilowatts (steady-state) if the compressor is running.

   c. 0.400 – 1.000 kilowatts if the defrost cycle is operating. It is possible that you will meter during the defrost time of an automatic defrost unit. Defrosters typically draw 0.400 kilowatts or more, and can dramatically increase the temperature in the freezer during operation. These defrost times typically occur at the end of 6 - 12 hours of compressor run-time and last for about 20 minutes. During the defrost cycle, freezer temperatures can be

well above freezing for more than 30 minutes. At the conclusion of your test, check the “high” reached during the test by the thermometer probe in the freezer. If this reading shows that a defrost cycle has occurred during your test, you must retest the unit. It is estimated that defrost-run time increases the annual consumption by 8-10 percent.

10. Record the temperature around the outside of the unit (the Present Ambient Temperature (PAT)) with the main body of your high/low recording thermometer. If the unit is in a nook or airflow is obstructed around it, try to get a reading on all sides for determining an average.
11. Survey the area for sources of heat that are likely to influence refrigerator/freezer energy use during the year. Influences include adjacent ranges, wood stoves, solar gain from adjacent windows, and heat distribution terminal devices. Ask the occupants about the room temperature over the entire year. The purpose of this quick survey is to guide your comments during the applicant education process, and to help you determine the average annual ambient temperature (AAAT).
12. At the end of the two-hour (or more) metering period:
    a. Check the high temperature reading on the remote bulb of the thermometer to determine if the refrigerator entered the defrost cycle during your metering. If it did, you must retest.

    Note: This step is not necessary for manual defrost refrigerators.

    b. Record the kWh/yr. estimate and the PAT and AAAT temperatures to determine the temperature-adjusted kWh/yr.
    c. 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.
13. 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.
14. All replacement refrigerators shall be white in color, unless the client is willing to pay the cost difference for the color of their choice.

15. Go through the applicant education process, whether or not refrigerator(s) and/or freezer(s) are being replaced.
16. The work orders must show the manufacturer, model number, and the vendor job number.
17. 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.
18. The vendor shall make sure that the new refrigerator is level and plumb.
19. The vendor obtains client signatures on a vendor-supplied form to verify delivery and removal of appliance(s).
20. 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[16]

12.4.1 Introduction

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.

12.4.2 Inspection and Client Education

12.4.2.1 *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

[16] Metered testing of carbon monoxide emissions from range top burners or bake ovens is not required by this procedure; however, MaineHousing recommends metered testing. For an acceptable protocol for metered testing of carbon monoxide emissions in the field, see www.karg.com/rangeprotocol.htm.

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.

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, 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. 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 and suggest that they have the range repaired or replaced.

12.4.2.2 *Client Education*

Educating the client is a 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."[17]

The final inspection must be performed by a certified energy auditor other than the initial auditor.

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[18] 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 on page 5.
2. The inspecting energy auditor is responsible for ensuring all items specified in the work order have been completed as prescribed in the task code and in a professional and workmanlike manner.

[17] 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).

[18] Please see the Maine Weatherization Program Section 106 Checklist.

3. The energy auditor shall assess the job to ensure that the contractor has not damaged any existing finishes and items in the home.
4. The energy auditor shall also ensure that the contractor or crew have left the dwelling in a clean and orderly manner.
5. The work order shall be followed at all times during the final inspection.
    a. Any items that have not been completed in accordance with the 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 energy auditor 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.
6. The inspecting energy auditor is responsible for obtaining all the proper homeowner signatures on the final sign-off for the project.
7. 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 must 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 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 weatherstripped. 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 weatherstripped.
3. Make sure knee wall access doors are properly insulated, weatherstripped, 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. Refer to Section 1.6 page 5.
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 on page 69.
2. Make sure that all foundation air sealing has been completed.
3. 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.

4. Verify that all insulation installation required by the work order has been properly installed.
5. Verify that an appropriate ground cover has been installed in crawl spaces, when warranted and possible.
6. Verify that water lines have been protected from freezing, if necessary.
7. Verify that damaged or missing exterior doors have been repaired or replaced and that they are weatherstripped and insulated.

13.6 Inspection of Dryer Vent

1. 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 on page 33

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 37 on page 37.
2. Verify that all exhaust fans comply with Section 4.16 on page 33, ASHRAE Standard 62.2-2010.
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.

14 Diagnostic Testing Procedures

14.1 Blower Door Testing

14.1.1 Introduction

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).

14.1.2 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.

14.1.3 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. 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.

14.1.4 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 are 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.[19]

The lowest AST used shall be 1000 CFM_{50}.

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

1. Air Sealing Target (AST) CFM_{50}, or
2. The Depressurization Tightness Limit CFM_{50}. The DTL CFM_{50} value shall be based on the post-weatherization condition of the dwelling (exhaust appliances and vented combustion appliances). Refer to Section 14.3 on page 147 for calculation details.

If the dwelling ends up tighter than the Air Sealing Limit (ASL), ensure that:

1. All combustion appliances are drafting properly and not spilling (see Section 14.8 on page 157 for worst-case depressurization testing details); and
2. Minimum ventilation for acceptable indoor air quality is installed in accordance with ASHRAE 62.2-2010. See Section 4.16 on page 33 for details.

14.3 Depressurization Tightness Limit (DTL)

14.3.1 Introduction

If the dwelling has open-combustion appliances, the Depressurization Tightness Limit (DTL) must be calculated before weatherization work begins.

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

[19] 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. On the other hand, if the basement is not considered a part of the thermal/pressure envelope, none of its volume would be included in the determination of the AST and the basement door would be closed during any blower door testing.

If the energy auditor expects exhaust fans will be added to the dwelling in order to comply with ASHRAE 62.2-2010, 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.

14.3.2 DTL Procedure

Maine Housing recognizes two options for determining the DTL when open-combustion appliances are present. The first is a quick field reference guide[20] created my MaineHousing and the second is the DTL feature of the Zip Test Pro™ software package.

1. The DTL reference guide, or
2. Use the DTL feature in the ZipTest Pro™ software package loaded into the Texas Instruments TI-86 and TI-89 calculators to calculate the dwelling DTL.

For either of these methods:

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

[20] The title of this chart is “Depressurization Values (-Pascals)”, dated July 12, 2011.

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.

Table 14-2

Combustion Appliance Depressurization Limits

Appliance Type	***Maximum Depressurization Limit, Pascals***
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 limit for combustion safety. Use this as a low-limit to house tightening. For example, if the DTL is 1600 CFM_{50}, instruct the crew or contractor not to tighten to below 1600 CMF_{50}. See Section 14.2 on page 146 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

14.4.1 Introduction

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.

14.4.2 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.

14.4.3 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.
   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). It is preferred to drill a test hole near each of the four corners of the supply plenum, check the supply-air temperature in each, and average these readings for use as the supply temperature. 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). If access is available, it is preferred to drill a test hole near each of the four corners of the supply plenum, check the supply-air temperature in each, and average these readings for use as the supply temperature.
   b. *Return side:* Drill a hole and insert the thermometer into the return plenum approximately 2 feet before the filter.
   c. 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.

14.7 Pressure Pan Testing Procedures for Manufactured Homes[21]

14.7.1 Introduction

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

[21] 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.

duct leakage directly; they infer leakage to the outdoors by reading the pressure at individual registers. Refer to Section 11.1.1.2 on page 117 for specific manufactured home duct leakage standards.

14.7.2 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.
    b. If access to a register or grille is difficult, for example at 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 pressure pan readings on the MaineHousing field form before and after duct sealing activities to get an idea of the effectiveness of the sealing. It will sometimes be useful to record readings during duct sealing. Always start your measurements using the blower door as a reference point and work clockwise around the dwelling.
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.
13. Record the pre- and post-weatherization readings on the appropriate page of the approved field form.

14.8 Worst-Case Depressurization Testing

14.8.1 Introduction

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 certified 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 is likely to 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.

14.8.2 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.

14.8.3 Test Procedure

"Worst-case" is defined as the configuration of the house that results in the greatest negative pressure *in the combustion appliance zone* (CAZ).

1. 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.

14.8.4 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.
8. 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. Record the baseline pressure on the approved field form.

14.8.5 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 8 above.
   a. The blower door must be used to simulate the CFM draw of a working fireplace. Use a nominal exhaust rate of 300 CFM.

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.

2. 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 backdrafting or flame rollout. Try to activate the furnace blower without firing the furnace burner.

3. 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.

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 on page 51 and Section 14.4.3 on page 151 for this test.

a. 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.

4. 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.
5. 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.
6. 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.

14.8.6 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 14.3.2 on page 148, 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 14.8.7, 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 on page 23.

14.8.7 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 one minute of firing. If the appliance spills after one minute, it fails the spillage test.
3. When the appliance reaches steady-state conditions (stable temperature in the vent connector), measure the draft at the appropriate location.[22] The draft should comply with the draft values in Table 14-3 or 14-4. If the draft is weaker than the values in Table 14-3 or 14-4, the appliance fails the draft test.
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 100 ppm as-measured or 200 ppm air-free.
   a. If the CO levels are higher, the appliance must be cleaned and tuned and then retested for CO.
   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.

[22] In order to conduct this test, a valid Limited Energy Auditor Technicians license from the Oil and Solid Fuel or Propane and Natural Gas Board is required. A hole may not be drilled in a vent connector nor may any test probe be inserted in an existing vent connector hole without this license. Please refer to Section 2.2 on page 5 for more information.

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 or draft measurement 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.

Table 14-3

Atmospheric Gas Appliances, Category I Acceptable Draft Test Readings for Various Outdoor Temperature Ranges					
ºF	<20	21-40	41-60	61-80	>80
Pascals	-5	-4	-3	-2	-1
Water Column inches	-.02	-.016	-.012	-.008	-.004

Table 14-4

Low-Static Pressure Power Oil Burners Acceptable Draft Readings at Breech	
Draft Reading Location	***Acceptable Draft***
Vent Connector or Breech	-0.04 to -0.06 or -10 to -15 Pascals

14.9 Zone Pressure Diagnostics (ZPD) Testing

14.9.1 Introduction

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 required in cases where additional information is needed regarding the relative and absolute leakage of air barriers (pressure boundaries). These standards require ZPD testing for (refer to Section 6.5 on page 51 for details):

1. Verifying the effectiveness of attic air sealing, and
2. 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 also require the determination of *flows* across air barriers. These flows can be calculated with the steps of the ZPD procedures and a computer or a programmed calculator. 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 can 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.

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.

14.9.2 Test Procedures

1. Use the ZipTest Pro™ software package loaded in the Texas Instruments TI-86 or TI-89 calculator 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, both before and after you create a temporary hole for the add-a-hole test.[23]
   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.
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. Required testing includes from house to attic and from house to attached or tuck-under garages. See Section 6.5 on page 51 for details.
5. For primary zone ZPD testing, perform the add-a-hole or open-a-door test using the ZipTest Pro™ software. The following steps are for the add-a-hole test:
   a. Set up the blower door for building depressurization.
   b. With a separate digital manometer located in the main body of the house, run a pressure hose from the left-hand channel to the zone you are testing (try to use a blue hose). Run another pressure hose from the house to the outdoors on the right-hand channel (try to use a green hose).
   c. Depressurize the building to –50 Pascals (read this pressure from the right-hand channel).
   d. On the ZPD manometer, read the left-hand channel pressure.
   e. Measure, record, and enter the pressure from the building to the zone.

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

f. On the ZPD manometer, move the pressure hose (green) from the lower tap on right-hand channel to the upper tap on channel left-hand channel.
g. With the hoses on these taps, measure, record, and enter the pressure from the zone to the outdoors that shows on the left-hand channel.
h. Determine where a temporary hole will be created – either between the building and the zone, or between the zone and the outdoors.
i. Enter the location of the created hole in the ZipTest Pro™ software – either in the building-to-zone air barrier, or in the zone-to-outdoor barrier.
j. Measure, record, and enter the size of the hole in square inches. It is best to lower the air barrier pressure difference where the hole is added by 15 or more Pascals.
k. Make certain that the house-to-outdoor pressure is brought back up to -50 Pascals 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.*
l. On the digital manometer, move the pressure hose (green) from the top tap on the left-hand channel to the bottom tap on the right-hand channel.
m. 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.
n. On the ZPD manometer, move the pressure hose (green) from the lower tap on the right-hand channel to the upper tap on left-hand channel.
o. 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.
p. With all the input data entered in the calculator, press “ENTER” for the calculation of the answers.
q. 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.
r. Based on the ZPD results, air seal as necessary.

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

6. The ZipTest Pro™ 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 ZipTest Pro™ software. There are significant limitations to the diagnostic accuracy of secondary zone testing.

15 Personnel Knowledge, Skills, and Abilities

The competencies and skills of Maine Weatherization Program weatherization personnel are important to define and achieve. The field of low-income weatherization has changed significantly during that last ten years; it is important that experienced weatherization staff adjust to these changes. The weatherization personnel knowledge, skills, and abilities listed in this section ensure that Maine weatherization staff remain at the forefront of this trend and bring the professionalism to their work that clients deserve.

Knowledge, Skills, and Abilities (KSAs)

1. KSAs identify the minimum knowledge, skills, and abilities that a skilled worker should possess to perform high quality weatherization work.
2. Efforts should be made by MaineHousing to provide training and other activities that allow the weatherization personnel to achieve these minimum KSAs.
3. Weatherization personnel should strive to achieve the level of professionalism inherent in these KSAs. These efforts include:
   a. Providing appropriate training opportunities.
   b. Setting up and maintaining a process for certification and certification renewal.
4. Over time, these KSAs will evolve; more items will be added and some may be dropped from the lists that follow.
5. The knowledge, skills, and abilities listed in this section are from Part II of *Workforce Guidelines for Home Energy Upgrades*, published by the Department of Energy in 2011.

The weatherization job categories included in this chapter are:

1. Energy auditor
2. Crew chief
3. Installer
4. Final inspector

15.1 Energy Auditor

An Energy Auditor is a building analyst that evaluates and analyzes buildings and their energy efficiency, and health and safety aspects by gathering empirical data, conducting tests and using energy modeling software with the goal of identifying areas for savings, reducing energy consumption, improving health and safety, and increasing the lifespan of a building while also improving the quality of life and comfort for building occupants.

15.1.1 Demonstrating Professional Energy Auditor Conduct

1. Establish Client Relations for an Energy Audit
    a. Ability to:
        i. Conduct client introductions
        ii. Conduct client interviews
        iii. Complete client questionnaires
        iv. Explain the purposes of the visit
        v. Set the client expectations and responsibilities (pre and post audit)
        vi. Establish the client plan of action
        vii. Engage the client in the actual testing
        viii. Obtain client signatures on forms (lead forms, etc.)
        ix. Serve as a liaison between the client and the contractors
        x. Ability to work independently
    b. Knowledge of:
        i. Building science
        ii. Codes of conduct
        iii. Forms (Lead safety forms, etc.)
        iv. Funding sources/financing
        v. Health and safety issues
        vi. Interviewing techniques
        vii. The program, agency or organization which the energy auditor represents
    c. Skills in:
        i. Communication
        ii. Listening
        iii. Presenting information
        iv. Time management
2. Represent the Program/Agency/Organization
    a. Ability to:

i. Communicate with crews and subcontractors
ii. Complete program/agency/organization reports

b. Knowledge of:
i. Construction processes and techniques
ii. Program reports

c. Skill in:
i. Communication

3. Maintain Professionalism
a. Ability to:
i. Complete continuing education
ii. Maintain certifications
iii. Acquire new certifications

b. Knowledge of:
i. Appropriate dress for the situation
ii. Certification requirements for energy auditors
iii. Continuing education requirements for energy auditors

15.1.2 Collecting Building Information for an Energy Audit

5. Document energy consumption
a. Ability to:
i. Obtain 12 months of client utility bills
ii. Obtain annual fuel delivery information (oil, propane, etc.)

b. Knowledge of:
i. How to access utility information
ii. Utility bill component interpretation

c. Skill in:
i. Calculating base loads, the area and volume of building spaces, etc.
ii. Basic math

2. Document the building history
a. Ability to:
i. Determine the age of the original structure
ii. Determine the age of any additions or improvements
iii. Determine if the building has any historical significance

b. Knowledge of:
i. How to access building permit history

ii. How to access tax files

3. Conduct a physical/visual inspection
   a. Ability to:
      i. Walk around the exterior of the building
      ii. Locate holes, chimneys, gutters, vent pipes, soffits, fascia, peeling paint, foundation integrity, areas of infiltration and exfiltration, exhaust fan penetrations, accesses, crawlspaces, roof vents, land grading, shading, building orientation, anomalies
      iii. Walk around the interior of the building
      iv. Check for pest/vermin infestations, evidence of leaking or water damage, holes, chimneys, vent pipes, peeling paint, foundation integrity, areas of infiltration and exfiltration, exhaust fan penetrations, accesses, crawlspaces, roof vents, structural damage
      v. Identify hidden rooms or spaces
      vi. Determine the exterior façade materials (siding, brick, etc.)
      vii. Identify issues that would interfere with or prevent tests
      viii. Identify hazardous materials in the building
      ix. Identify health and safety issues (clutter, bleach stored next to a furnace, etc.)
      x. Perform visual inspection of vented combustion appliance venting configuration
      xi. Detect unusual odors
      xii. Photograph and document conditions
   b. Knowledge of:
      i. General construction
      ii. Codes and standards adopted by the local jurisdiction
      iii. Combustion appliance venting procedures
      iv. Hazardous materials
      v. Issues that pose a health and/or safety risk
      vi. NFPA 211
      vii. Situations that pose a health and/or safety risk
      viii. Effects of moisture
      ix. Sources of moisture
      x. What to look for when conducting a physical/visual inspection

c. Skill in:
    i. Attention to detail

4. Collect appliance information
    a. Ability to:
        i. Collect refrigerator/freezer label data and documentation
        ii. Collect heating/cooling appliance label data and documentation
        iii. Identify heating/cooling appliance fuel type
        iv. Collect domestic water heater label data and documentation
        v. Collect washer/dryer label data and documentation
        vi. Collect mechanical ventilation label data and documentation
        vii. Collect dishwasher label data and documentation
        viii. Collect shower head flow rates
        ix. Collect dehumidifier label data and documentation
        x. Collect stove/oven appliance label data and documentation
        xi. Identify stoves/ovens appliance fuel type
        xii. Collect unvented space heater label data and documentation
        xiii. Identify other components related to the HVAC appliances (expansion tanks, fill valves, remote compressors, etc.)
        xiv. Identify other components related to the domestic water heater appliance (storage tanks, mixing valves, etc.)
        xv. Identify safety features related to the HVAC and domestic water heater appliances
    b. Knowledge of:
        i. Appliances
        ii. Codes and standards adopted by the local jurisdiction
        iii. Domestic water heater components and operation
        iv. Heating/cooling system How to read a meter
        v. How to read and interpret appliance labels
        vi. Mechanical ventilation equipment
        vii. Safety issues associated with domestic water heaters
        viii. Shower head operations and flow rates
        ix. Various appliance fuel types
    c. Skill in:
        i. Penmanship
        ii. Attention to detail

5. Collect electrical baseload data
    a. Ability to:
        i. Conduct a lighting audit
        ii. Count the number of people in the house
        iii. Determine if dishwasher is present
        iv. Determine if the domestic water is fuel fired or electric
        v. Collect client lifestyle information (TV usage, Xboxes, etc.)
        vi. Meter the refrigerator
        vii. Look for additional usage sources (hot tubs, pool pumps, pool heaters, fish ponds, fountains, etc.)
    b. Knowledge of:
        i. Fuel-fired versus electric domestic water heaters
        ii. How lifestyle affects energy consumption
        iii. How to analyze a utility bill
        iv. How to diagnose high electric/gas usage
        v. How to read an electric meter
        vi. Refrigerator gasket seal conditions
    c. Skill in:
        i. Basic math
6. Collect building measurements
    a. Ability to:
        i. Measure walls
        ii. Measure roofs
        iii. Measure windows
        iv. Measure doors
        v. Measure perimeter
        vi. Measure radiators
        vii. Measure foundation height
        viii. Measure attic venting
        ix. Measure attic spaces
        x. Measure area and volume of the building envelope
    b. Knowledge of:
        i. How to calculate the area and volume of the building envelope
        ii. How to identify the pressure boundary
        iii. How to identify the thermal boundary

iv. How to measure building components (doors, windows, etc.)
v. Various building components

c. Skill in:
i. Measuring
ii. Attention to detail
iii. Basic math

7. Collect health and safety data
a. Ability to:
i. Locate existing smoke/CO alarms
ii. Determine age of smoke/CO alarms
iii. Determine if smoke detectors/CO are hardwired or battery
iv. Verify clothes dryer is properly vented to exterior
v. Verify all exhaust fans are properly vented to exterior
vi. Identify existence of any possible hazardous materials/conditions
vii. Identify knob-and-tube wiring
viii. Identify moisture issues (standing water, condensation, plumbing leaks, mold, etc.).
ix. Identify electrical hazards (frayed wiring, open junction boxes, unkempt wires, overloaded circuits, etc.)
x. Identify suspect asbestos
xi. Identify lead based paint hazards
xii. Identify propane fueled appliances
xiii. Identify unvented combustion appliances
xiv. Identify properly operating back draft damper

b. Knowledge of:
i. Proper locations for smoke/CO alarms
ii. Venting requirements for appliances
iii. Conditions that signify moisture
iv. Domestic water heater safety
v. Electrical hazards
vi. Hazardous materials
vii. Heating system safety
viii. How to determine if knob-and-tube wiring is active
ix. Issues and hazards associated with asbestos
x. Issues and hazards associated with lead based paint

xi. Water heater regulations for manufactured homes
xii. Rules and regulations pertaining to lead and asbestos
xiii. Smoke/CO alarm operations

8. Collect mechanical ventilation data
   a. Ability to:
      i. Review manufacturer's specifications for exhaust fans
      ii. Determine the volume of the affected space
      iii. Determine the type of control
      iv. Identify the size of the registers/grilles
      v. Determine condition of the ventilation ductwork/piping (pitch, insulation, size, material, elbows, length to run, etc.)
      vi. Calculate volume
   b. Knowledge of:
      i. The different controls and motors
      ii. Types of ventilation materials
      iii. Ventilation ductwork
      iv. Ventilation standards and local codes
9. Identify building insulation (attic, walls, floors and foundation)
   a. Ability to:
      i. Identify insulation type
      ii. Identify insulation amount (thickness, etc.)
      iii. Identify insulation condition
      iv. Identify presence and placement of vapor retarder
      v. Identify location of insulation (exposure, aligned with pressure boundary, etc.)
      vi. Identify areas of insulation opportunities for savings
      vii. Probe
      viii. Work in confined spaces
   b. Knowledge of:
      i. Building science
      ii. Insulation effectiveness
      iii. Insulation R-Values
      iv. Insulation placement
      v. OSHA safety requirements
10. Collect attic data
    a. Ability to:

i. Identify attic components
ii. Measure attic/roof cavities
iii. Measure attic areas
iv. Measure attic framing
v. Determine existing ventilation (soffit, can, ridge, type and size, power ventilators, etc.)
vi. Identify sources/signs of water damage
vii. Identify air leakage points
viii. Identify point(s) of access
ix. Identify electrical hazards
x. Identify pest/vermin infestations
xi. Determine structural integrity
xii. Identify whole-house cooling fan
xiii. Determine attic uses
xiv. Note the existence of radiant barriers
xv. Identify existence of baffles
xvi. Use ladders
xvii. Work in confined spaces

b. Knowledge of:
i. Attic components
ii. Electrical hazards
iii. General construction terms
iv. How to calculate the area and volume of building spaces
v. Air leakage points
vi. Safety hazards in an attic (nails, rafters, heat exposure, etc.)
vii. Signs of water damage
viii. Signs of pest/vermin infestations
ix. Thermography
x. Types of ladders based on the situation
xi. Ventilation requirements

11. Collect wall data
a. Ability to:
i. Identify wall type (interior, exterior, components)
ii. Identify framing method
iii. Measure wall areas
iv. Identify wall orientation

v. Identify cavity depth
vi. Identify source and signs of any water damage
vii. Identify infiltration points
viii. Identify signs of pest/vermin infestation
ix. Identify orientation using online mapping tools
x. Use a compass

b. Knowledge of:
i. General construction
ii. Building science
iii. Compass orientations
iv. Air leakage points
v. Typical wall framing and components

c. Skills in:
i. Basic math
ii. Logical thinking

12. Collect window data
a. Ability to:
i. Identify window type (jalousie, awning, single-hung, double hung, etc.)
ii. Identify window frame type
iii. Identify window glazing type
iv. Identify exterior shading
v. Identify window operation/leakiness
vi. Measure window area
vii. Count number of windows
viii. Identify window orientation
ix. Identify general window conditions

b. Knowledge of:
i. Code requirements pertaining to window glazing (walkways, etc.)
ii. OSHA safety requirements
iii. State Historic Preservation Office (SHPO) requirements
iv. Window construction, components and nomenclature

13. Collect door data
a. Ability to:
i. Identify door type and swing

ii. Measure door area
iii. Count number of doors
iv. Identify door conditions
v. Identify condition of door sweep and weather stripping
vi. Identify door hardware condition

b. Knowledge of:
i. Door components, hardware and nomenclature
ii. Door construction
iii. Door operation and adjustments

c. Skill in:
i. Basic math

14. Collect foundation data
a. Ability to:
i. Identify foundation types (crawlspace, basement, or slab)
ii. Identify foundation materials
iii. Measure floor areas
iv. Identify infiltration points
v. Measure exposed walls
vi. Measure thickness of foundations
vii. Identify sources and signs of moisture
viii. Identify points of access
ix. Identify electrical hazards
x. Identify signs of pest/vermin infestations
xi. Determine structural integrity
xii. Identify special equipment (sump pumps, etc.)
xiii. Measure the crawlspace ventilation
xiv. Record the location of any plumbing pipes
xv. Work in confined spaces

b. Knowledge of:
i. General construction
ii. Basic electricity
iii. Basic plumbing
iv. Building science
v. Codes and standards adopted by the local jurisdiction
vi. Crawlspace ventilation requirements, if any

vii. Foundation construction materials and methods
viii. OSHA safety requirements
ix. Potential sources of moisture
x. Signs of moisture
xi. Signs of pests/vermin
xii. Signs of structural hazards on foundations
xiii. Structures typically found in foundations
xiv. Types of foundations

c. Skills in:
i. Observation

15. Collect roof data
a. Ability to:
i. Identify roof conditions
ii. Identify roof color
iii. Identify roofing materials (90 lb. paper, rubber, etc.)
iv. Identify condition of parapet walls
v. Identify roof penetrations
vi. Identify roof debris (garbage, old air conditioners, etc.)
vii. Identify roof ventilation (passive vents)
viii. Identify roof drainage
ix. Identify roof pitch
x. Measure roof area
xi. Note flashing condition
xii. Identify roof access
xiii. Identify roof exposure and orientation
xiv. Identify roof insulation (flat roof with no cavity and with rigid insulation)
xv. Work at heights
xvi. Determine roof pitch
xvii. Measure areas

b. Knowledge of:
i. General construction
ii. Insulation materials and methods
iii. OSHA safety requirements
iv. Roofing construction methods
v. Roofing materials

15.1.3 Testing the Building for an Energy Audit

1. Prepare for the test
    a. Ability to:
        i. Determine the test(s) to be performed
        ii. Inform the client of the test(s)
        iii. Gather the test tools/equipment
        iv. Prepare the building for testing based upon manufacturer's test equipment specifications
        v. Understand manufacturer's specifications
        vi. Use test equipment
    b. Knowledge of:
        vii. Building diagnostic testing
        viii. Building science
        ix. Test equipment
        x. Test protocols
    c. Skill in:
        i. Attention to detail
        ii. Communication
2. Meter the appliances
    a. Ability to:
        i. Inspect appliances for test accessibility
        ii. Plug appliances into the Watt-hour meter
        iii. Follow the manufacturer's guidelines for operation of the Watt-hour meter
        iv. Document findings with pictures/forms
        v. Read and interpret a Watt-hour meter
    b. Knowledge of:
        i. Electric appliance metering
        ii. Electric appliance safety
3. Conduct indoor air quality tests
    a. Ability to:
        i. Monitor the ambient CO tests throughout the building
        ii. Record the highest ambient CO reading
        iii. Find the source of the CO
        iv. Determine if the reading exceeds any applicable action levels

v. Identify conditions that promote mold growth (high humidity, cold surface condensation, etc.)
vi. Follow odors to find source of mildew
vii. Visually identify presence of mold-like substance
viii. Identify conditions that promote radon infiltration
ix. Measure the flow of mechanical ventilation
x. Document findings with pictures/forms
xi. Communicate meter results with clients
xii. Remain calm under stressful situations

b. Knowledge of:
i. ASHRAE maximum allowable CO exposure for living areas
ii. Carbon monoxide exposure symptoms
iii. Conditions that promote mold growth
iv. Conditions that promote radon infiltration
v. EPA action levels
vi. How to measure mechanical ventilation
vii. NIOSH recommended limit for occupational CO exposure
viii. OSHA permissible exposure limits

c. Skill in:
i. Remaining dedicated to the cause
ii. Detecting unusual odors

4. Perform combustion safety and efficiency tests
a. Ability to:
i. Visually inspect the fuel supply lines
ii. Test for leakage in the fuel supply pipes
iii. Verify leaks with bubble solution
iv. Perform worst case depressurization test
v. Perform combustion spillage tests
vi. Perform draft tests
vii. Conduct combustion efficiency tests (oxygen, net stack temperature)
viii. Measure undiluted CO in combustion appliances
ix. Document findings with pictures/forms
x. Identify various heating systems
xi. Work in confined spaces

b. Knowledge of:

i. Back-draft test protocols
ii. Building science
iii. Codes and standards adopted by local jurisdiction
iv. Combustion efficiency tests
v. Fuel-line leak testing techniques
vi. Heating system configurations
vii. How to conduct draft tests
viii. How to inspect fuel supply lines
ix. How to measure CO in appliances
x. Nationally recognized combustion safety test protocols (BPI, Midwest Best Practices, etc.)
xi. Four vent categories as defined by the National Fuel Gas Code (NFPA 54)
xii. Various venting methods and three draft types
xiii. Understanding of "worst case" depressurization and how to achieve

5. Perform blower door test
   a. Ability to:
      i. Perform pre-blower door interior thermographic scan
      ii. Perform pre-blower door exterior thermographic scan
      iii. Follow manufacturer's specifications for conducting blower door tests
      iv. Perform thermographic scan during the blower door operation
      v. Perform zone pressure diagnostics (ZPD) to attic and attached garage
      vi. Locate points of infiltration/exfiltration
      vii. Document findings with pictures/forms
      viii. Determine the cost effective level of air sealing
      ix. Interpret blower door results
   b. Knowledge of:
      i. Advanced blower door diagnostics
      ii. Blower door testing procedures (pressurization, depressurization, etc.)
      iii. How to assemble and operate a blower door
      iv. How to evaluate zone pressures

v. Thermography
vi. Air sealing limit standards (DTL, AST, etc.)

c. Skill in:
i. Basic math

6. Perform HVAC distribution tests
a. Ability to:
i. Perform forced air system distribution leakage test
ii. Verify with building occupants if there is adequate heating and cooling in the building
iii. Measure room temperatures
iv. Measure the temperatures of the hydronic radiators
v. Perform air flow tests at the registers
vi. Measure temperature rise across heat exchangers
vii. Measure external static pressure of distribution system
viii. Inspect hydronic distribution (high, low, valves, etc.)
ix. Measure hydronic distribution (radiators, fin tube, etc.)
x. Perform pressure-balancing rooms tests (ducted air systems)
xi. Document findings with pictures/forms
xii. Work in confined spaces

b. Knowledge of:
i. HVAC testing protocols
ii. Air flow
iii. How to measure hydronic distribution
iv. HVAC terminology
v. Hydronic heating
vi. Manufacturer's specifications for forced air distribution systems
vii. Distribution system design

c. Skill in:
i. Communication
ii. Attention to detail

15.1.4 Evaluating Collected Energy Audit Data

1. Evaluate the health and safety of the building
a. Ability to:

i. Review collected data to determine if there is health and safety concern
ii. Determine if health and safety issues can be addressed through an energy-efficiency measure and therefore can fall within energy funding
iii. Determine the repairs needed
iv. Review the economics of the repairs to determine whether to repair or to defer

b. Knowledge of:
i. How to deal with special circumstances (mold, lead, asbestos, etc.)
ii. Construction repair methods
iii. Costs associated with repairs
iv. Energy funding

c. Skill in:
i. Basic math
ii. Cost estimating

2. Evaluate the durability/structural integrity of the building
a. Ability to:
i. Review collected data to determine if there is a durability/structural integrity issue
ii. Determine if the durability/structural integrity issues can be addressed through an energy-efficiency measure and therefore can fall within energy funding
iii. Determine the durability/structural integrity repairs
iv. Review the economics of the repairs to determine whether to repair or to defer

b. Knowledge of:
i. Codes and standards adopted by local jurisdiction
ii. Costs associated with structural repairs
iii. Energy funding
iv. Structural repair methods 9.21

c. Skill in:
i. Basic math
ii. Cost estimating

3. Evaluate the HVAC system

a. Ability to:
    i. Review collected data to determine if there is a HVAC system problem
    ii. Evaluate the HVAC system for health and safety concerns
    iii. Evaluate HVAC sizing for potential replacement or upgrades
    iv. Evaluate the distribution (add trunk lines, radiators, etc. to rooms as needed)
    v. Evaluate fuel switching options
    vi. Evaluate the need to clean and tune versus replace
    vii. Evaluate the need for and supply of combustion air
    viii. Evaluate the HVAC system for other issues that lead to replacement or upgrades (condition, age, efficiency, etc.)
    ix. Identify duct sealing/insulation and pipe insulation opportunities
    x. Interpret software output
    xi. Perform load calculations
b. Knowledge of:
    i. • Air Conditioning Contractors of America (ACCA) manuals
    ii. • BTU content of fuels
    iii. • Energy funding
    iv. • Heating/cooling system operations
    v. • How to size HVAC systems
    vi. • HVAC load calculations
    vii. • HVAC system repair, replacement or upgrade costs
    viii. • Maximum allowable duct leakage
    ix. • Safety requirements
c. Skill in:
    i. Basic math
    ii. Communication
    iii. Attention to detail

4. Evaluation of mechanical ventilation
    a. Ability to:
        i. Review collected data to determine mechanical ventilation issues
        ii. Compare flow with ventilation specifications
        iii. Compare blower door results against IAQ standards

iv. Assess the need for and placement of additional mechanical ventilation
v. Assess the make-up air source and whether it needs to be filtered
vi. Determine the mechanical ventilation repairs, replacement and/or addition
vii. Review the economics of the repairs, replacements and/or additions to determine whether to proceed or to defer
viii. Determine the type of ventilation controls needed

b. Knowledge of:
i. Ventilation standard (ASHRAE 62.2-2010)
ii. Funding for ventilation systems
iii. IAQ standards
iv. Mechanical ventilation controls
v. Types of ventilation
vi. Ventilation flow
vii. Ventilation sizing

c. Skill in:
i. Basic math

5. Evaluate baseload energy use
a. Ability to:
i. Review collected data to determine if replacements or upgrades will reduce energy consumption
ii. Consider energy-efficient light bulbs for installation
iii. Review refrigerator/freezer data for economics of replacement
iv. Review domestic water heaters for economics of replacement or repair
v. Review domestic water heater pipe insulation opportunities
vi. Review domestic water heater insulation opportunities
vii. Review water-saving opportunities (water saving shower heads, etc.)
viii. Review domestic water heater thermostat setting

b. Knowledge of:
i. Codes and standards adopted by local jurisdiction
ii. Components of baseloads

iii. Energy funding
iv. How to calculate baseloads
v. Pipe insulation

6. Evaluate the foundation
   a. Ability to:
      i. Review collected data to determine foundation issues
      ii. Determine repairs needed
      iii. Review economics of repairs
      iv. Determine proper insulation location (floor or wall)
      v. Evaluate crawlspace venting needs, if any
      vi. Evaluate box sill insulation needs
      vii. Determine if perimeters need to be insulated
      viii. Identify type of insulation materials to be added
      ix. Calculate if adequate ventilation exists or should be added
      x. Evaluate the need for a ground cover, if any
   b. Knowledge of:
      i. Building science
      ii. Codes and standards adopted by local jurisdiction
      iii. Energy funding
      iv. Foundation construction techniques
      v. Foundation crawlspace ventilation
      vi. Foundation insulation
      vii. Foundation types
      viii. Foundation vapor barriers/retarders, if any
7. Evaluate the walls
   a. Ability to:
      i. Review collected data to determine wall issues
      ii. Evaluate repairs needed and structural integrity
      iii. Review the economics of repairs to determine whether to repair or defer
      iv. Determine proper insulation levels
      v. Identify type of insulation materials to be added
      vi. Determine square footage of area to be insulated
      vii. Ensure pressure plane and thermal boundary align
      viii. Ensure the vapor retarder is appropriately placed
   b. Knowledge of:

i. EPA and DOE lead and asbestos standards
ii. Building science
iii. Codes and standards adopted by local jurisdiction
iv. Energy funding
v. Insulation types and appropriateness
vi. Pressure planes and thermal boundaries
vii. Typical wall structures
viii. Vapor barriers/retarders in walls, if any

8. Evaluate the attic
   a. Ability to:
      i. Review collected data to determine attic issues
      ii. Evaluate structural integrity and repairs needed
      iii. Review economic of repairs to determine whether to repair or defer
      iv. Review insulation location
      v. Review insulation type
      vi. Evaluate whether insulation is appropriate for use
      vii. Ensure pressure boundary and thermal boundary align (air sealing)
      viii. Ensure the vapor retarder is appropriately placed, if needed
      ix. Evaluate attic ventilation, existing and required
      x. Assess fire hazards (lighting cans, electrical, etc.)
      xi. Evaluate the need for service access
   b. Knowledge of:
      i. Attic construction and materials
      ii. Attic fire hazards
      iii. Attic types
      iv. Attic ventilation
      v. Building science
      vi. Codes and standards adopted by local jurisdiction
      vii. Energy funding
      viii. Insulation types and appropriateness
      ix. Pressure planes and thermal boundaries
      x. Vapor barriers/retarders and their purpose
9. Evaluate the doors
   a. Ability to:

i. Review collected data to determine door issues
ii. Evaluate repairs needed and structural integrity (can frame support door replacement, etc.)
iii. Review economics of repairs to determine whether to repair or replace
iv. Evaluate the condition of storm doors (closers, etc.)

b. Knowledge of:
i. Codes and standards adopted by local jurisdiction
ii. Door framing structures and processes
iii. Door types
iv. Energy funding
v. Glass types

10. Evaluate the windows
a. Ability to:
i. Review collected data to determine window issues
ii. Evaluate repairs needed and structural integrity
iii. Review economic of repairs to determine whether to repair or replace
iv. Evaluate window components and performance

b. Knowledge of:
i. Building science
ii. Codes and standards adopted by local jurisdiction
iii. Energy funding
iv. Window components
v. Window glazing
vi. Window types

11. Enter data into energy audit software tool
a. Ability to:
i. Gather all information and data pertaining to the audit
ii. Enter the data into energy audit software tool, NEAT or MHEA
iii. Analyze the output from the software
iv. Produce a cost and savings report
v. Use a computer

b. Knowledge of:
i. Basic construction terms

ii. Building science
iii. Energy audit software tool, NEAT and MHEA

12. Determine the work scope
    a. Ability to:
        i. Determine the health and safety measures
        ii. Determine the building durability measures
        iii. Determine the energy measures based on the SIR
        iv. Provide analysis reports (work order)
        v. Create reports
        vi. Create work specifications
    b. Knowledge of:
        i. Building science
        ii. Codes and standards adopted by local jurisdiction
        iii. Construction practices and terms
        iv. Energy modeling software
        v. Program rules and standards
    c. Skill in:
        i. Computer usage

15.2 Crew Chief

A crew chief is responsible for supervising the retrofitting activities specified in the scope of work. He or she is responsible for interacting with the client plus managing personnel and materials on the job site in a safe and effective manner. The crew chief is responsible for quality control, testing procedures, documentation, and conducting a final walk through to ensure that all work is completed in a satisfactory manner.

We recognize DOE is working on KSAs for crew chief; once, finalized, they will be adopted and in the Standards under this section.

15.3 Installer

An installer installs energy-efficiency measures to single family or 2-4 unit-homes using a variety of building science practices and techniques.

15.3.1 Maintain Safety

1. Follow work rules of jurisdiction having authority
    a. Ability to:

i. Read or hear safety documents
ii. Implement safety procedures
iii. Report safety concerns and violations
iv. Wear safety equipment
v. Attend safety meetings/trainings
vi. Request safety training
vii. Install safety guards

b. Knowledge of:
i. Installation procedures
ii. Manufacturer's specifications
iii. OSHA
iv. Safety systems

2. Handle materials/equipment according to manufacturer's specifications
a. Ability to:
i. Read or hear manufacturer's specifications or MSDS
ii. Store or maintain materials/equipment according to manufacturer's specifications
b. Knowledge of:
i. Manufacturer's specifications
3. Handle tools according to manufacturer's specifications
a. Ability to:
i. Read or hear manufacturer's specifications or MSDS
ii. Store or maintain materials/equipment according to manufacturer's specifications
b. Knowledge of:
i. Manufacturer's specifications

15.3.2 Prepare for the Job Before Arriving at Job Site

1. Attend training
a. Ability to:
i. Participate in training
ii. Identify self-strengths and weaknesses
iii. Modify installation practice based on training
iv. Sign in to training
b. Knowledge of:

i. Existing practice
ii. Safety procedures

2. Gather materials and supplies
   a. Ability to:
      i. Review materials list
      ii. Compare materials to work scope
      iii. Verify and protect the condition of materials
      iv. Organize materials
      v. Report missing or deficient materials
   b. Knowledge of:
      i. Compatibility
      ii. Material handling
      iii. Materials
      iv. Material limits
      v. MSDS
      vi. Physical limits of materials
      vii. Work scope
3. Gather tools
   a. Ability to:
      i. Review tool list
      ii. Compare tools to work scope
      iii. Verify and protect tool condition
      iv. Load and unload tools
      v. Report missing or deficient tools
      vi. Modify tools for specific job requirements
   b. Knowledge of:
      i. Work scope
      ii. Manufacturer's specifications
      iii. Materials handling
      iv. Lifting safety
      v. Normal tool operations

15.3.3 Prepare and Maintain Tools and Materials at Site

1. Set up tools
   a. Ability to:
      i. Unload tools from vehicle

ii. Connect attachments
iii. Plug in tools
iv. Verify operational status
v. Perform routine maintenance
vi. Report deficiencies

b. Knowledge of:
i. Carrying techniques
ii. Double insulated tools
iii. Electrical safety
iv. GFCI
v. Lifting techniques
vi. Manufacturer's specifications
vii. Normal operations
viii. Tool recognition
ix. Work scope

2. Set up materials
a. Ability to:
i. Unload materials from vehicle
ii. Organize materials
iii. Confirm materials match work scope
iv. Maintain integrity of materials
v. Report deficiencies

b. Knowledge of:
i. Job site
ii. Lifting techniques
iii. Materials
iv. Materials limits and characteristics
v. Work scope

15.3.4 Prepare and Maintain Job Site

1. Attend job site safety meeting
a. Ability to:
i. Attend
ii. Participate
iii. Sign in

2. Implement safety protocol (rigging, ventilation, blocking)

a. Ability to:
    i. Set up safety masking an drop cloths
    ii. Set up ventilation in confined spaces
    iii. Set up task lighting
    iv. Hook up to fall protection
    v. Set up ladders, scaffolding, climbing equipment
    vi. Put on personal protective equipment
    vii. Lock out/tag out
    viii. Inspect work area for hazards
    ix. Report work area hazards
b. Knowledge of:
    i. Combustibles
    ii. Confined spaces
    iii. Electrical safety
    iv. EPA lead safety
    v. Equipment operation
    vi. Fall protection
    vii. Fit test
    viii. Hazard recognition
    ix. Lanyards
    x. Local codes
    xi. Manufacturer’s specifications
    xii. Materials
    xiii. OSHA
    xiv. Personal protection
    xv. Safety protocols
    xvi. Ventilation systems and requirements
    xvii. Work scope

3. Use protective barriers (drop clothes)
    a. Ability to:
        i. Move furniture (confirm permission)
        ii. Cover furniture/storage areas/clothes in closets
        iii. Protect furniture
        iv. Protect floors
        v. Follow safe practices, including lead safe practices

vi. Place drop cloths, tack mats
vii. Use designated facilities (eating, bathroom, smoke break)

b. Knowledge of:
i. Adjacent characteristics
ii. Electronics
iii. EPA lead safety
iv. Flooring characteristics
v. Lifting techniques
vi. Materials characteristics
vii. Safe practices
viii. Work scope

4. Report Pre-existing conditions that are not in work scope
a. Ability to:
i. Identify pre-existing conditions (aesthetic/structural)
ii. Report pre-existing conditions
iii. Report difficult-to-access places
b. Knowledge of:
i. General construction
ii. Work scope
5. Protect exterior environment
a. Ability to:
i. Control dust and debris created by equipment from construction activities
ii. Protect landscaping
iii. Check for oil leaks
iv. Report mishaps (spills, cracks)
b. Knowledge of:
i. Work scope
ii. Retaining walls
iii. General landscape knowledge
iv. Containment requirements

15.3.5 Implement Work Scope

1. Locate specific work areas
a. Ability to:
i. Review the work scope

ii. Walk the job site
iii. Find mechanicals

b. Knowledge of:
i. General construction
ii. General mechanical knowledge
iii. Job site specifics
iv. Work scope

2. Verify access to work areas
a. Ability to:
i. Confirm approval for start of work
ii. Work with crew chief to get access to areas
iii. Remove obstructions for start of work

b. Knowledge of:
i. Work scope
ii. General construction
iii. Job site
iv. Lifting safety

3. Install air sealing measures
a. Ability to:
i. Identify leaks and bypasses
ii. Select materials
iii. Look for code violations
iv. Block large openings
v. Hand seal gaps and cracks
vi. Check tightness and durability of seal

b. Knowledge of:
i. Clearances
ii. Fire code
iii. Framing components
iv. Operation of a blower door
v. Use of tracer smoke
vi. Leakage sites
vii. Material capability
viii. Material durability
ix. Material strength

x. Penetrations
xi. Tolerances

4. Install loose fill insulation
   a. Ability to:
      i. Confirm air sealing is complete
      ii. Confirm exhaust fans are ducted to the outdoors and insulated
      iii. Confirm HVAC duct work is intact, sealed, supported, and insulated
      iv. Confirm clearance to combustibles
      v. Confirm clearance for electrical issues
      vi. Install baffles, blocking, platforms, and insulation dams
      vii. Install vertical insulation
      viii. Install horizontal insulation
      ix. Compare material use to coverage required (bags used)
   b. Knowledge of:
      i. Clearance
      ii. Combustibles
      iii. Component analysis
      iv. Coverage charts
      v. Depth markers
      vi. Duct requirements
      vii. General carpentry
      viii. How to draw a floor plan
      ix. Operation of a blower door
      x. Insulation installation requirements
      xi. Manufacturer's specifications for installation
      xii. Materials
      xiii. Rigid insulation board types
      xiv. R-values
      xv. Termination requirements
      xvi. Thermal barriers
5. Install or patch moisture barriers
   a. Ability to:
      i. Confirm positive drainage
      ii. Remove all organic/inorganic materials

iii. Install moisture barrier and seal joints and seams
iv. Verify flashing is installed
v. Identify and locate moisture sources
vi. Report bulk moisture concerns

b. Knowledge of:
i. Flashing locations
ii. Grading issues
iii. Gravity
iv. Installation standards
v. Materials
vi. Moisture problems
vii. Moisture symptoms
viii. Roof slope changes
ix. Where to look for moisture

6. Install ventilation
a. Ability to:
i. Uncrate equipment
ii. Remove old equipment
iii. Confirm electrical and plumbing requirements are in place
iv. Cut openings in building
v. Install venting system and vent terminations
vi. Install, air seal, and insulate ducting system
vii. Confirm installation is complete

b. Knowledge of:
i. Building science
ii. Equipment disconnects
iii. Equipment requirements
iv. Equipment shutoffs
v. Framing
vi. Conducting duct leakage testing
vii. Reading duct diagrams
viii. Manufacturer’s specifications
ix. Penetration locations
x. Protection of materials
xi. Smoke testing joints

xii. Use of power tools
xiii. Utility knife safety

7. Install mechanical systems
   a. Ability to:
      i. Uncrate and verify equipment
      ii. Remove old equipment
      iii. Confirm electrical requirements are in place
      iv. Confirm plumbing requirements are in place
      v. Confirm fuel requirements are in place
      vi. Cut openings in building
      vii. Install equipment and renewable systems
      viii. Install or reconnect return and distribution systems (hot water, steam, hydronic, forces air, etc.)
      ix. Install, air seal, and insulate ducting system
      x. Confirm installation is complete
      xi. Connect or install combustion vent system
   b. Knowledge of:
      i. Cavity protection
      ii. Circuit testers
      iii. Circulating pumps
      iv. Code requirements
      v. Connectors
      vi. Disconnects
      vii. EPA safety
      viii. Equipment requirements
      ix. Flow
      x. Flow through system
      xi. Framing
      xii. General carpentry
      xiii. Locking joints
      xiv. Insulation
      xv. Leakage of ducts
      xvi. Manufacturer’s specifications
      xvii. Mastics
      xviii. Penetration locations
      xix. Piping

xx. Protection of materials
xxi. Sheet metal
xxii. Shutoffs
xxiii. Slope
xxiv. System attachments
xxv. Temperature of conditioned space
xxvi. Use of power tools
xxvii. Utility knife safety

8. Commission equipment or systems
   a. Ability to:
      i. Verify all connections
      ii. Verify operation
      iii. Adjust to OEM specifications
      iv. Report results
   b. Knowledge of:
      i. Design specifications
      ii. Gas pressure tests
      iii. Manufacturer's specifications
      iv. OEM specifications
      v. Types of materials for appliances
9. Confirm and ensure combustion safety
   a. Ability to:
      i. Check for safety issues, including ambient gas
      ii. Set up house for natural conditions
      iii. Run combustion equipment in proper sequence
      iv. Set up for and determine worst-case depressurization
      v. Check spillage, draft, and CO under worst-case depressurization
      vi. Report findings
   b. Knowledge of:
      i. Combustion safety testing
      ii. Draft testing
      iii. Natural conditions
      iv. Safety protocols
      v. Use of tools
      vi. Venting systems

vii. Worst-case depressurization setup

10. Install dense pack insulation
    a. Ability to:
        i. Set up and tune machine for application
        ii. Locate insulation fill hole locations
        iii. Remove siding without damage
        iv. Confirm building component integrity
        v. Get access to all building cavities and locate all horizontal blocks
        vi. Check for hazards
        vii. Fill first cavity and confirm density stops air leakage
        viii. Readjust machine, if required
        ix. Fill all cavities
        x. Compare material use to coverage required (bags consumed)
        xi. Plug holes, patch weather barrier, replace siding, caulk joints
    b. Knowledge of:
        i. Basic math skills
        ii. Blower door testing
        iii. Building structures
        iv. Dense pack installation procedures
        v. Siding removal
        vi. Proper location for fill holes
        vii. Equipment
        viii. Framing
        ix. General carpentry
        x. Hazards
        xi. Probing the wall
        xii. Limitations of components
        xiii. Materials
        xiv. Tracer smoke testing
        xv. Strength of components
        xvi. Testing procedures
11. Install windows and doors
    a. Ability to:
        i. Remove old windows and doors

ii. Check and install waterproofing, flashing
iii. Install windows and doors
iv. Install air barrier and ensure proper water drainage
v. Verify air tightness and drainage

b. Knowledge of:
i. Measurement accuracy, up to 1/16 inch
ii. Basic math skills
iii. Building techniques
iv. Building codes
v. Building practices
vi. Building science
vii. Drainage planes
viii. EPA lead safety
ix. Fasteners
x. Flashing techniques
xi. General carpentry
xii. Manufacturer's specifications
xiii. Materials
xiv. Pressure
xv. Quality installations
xvi. Vapor barriers/retarders
xvii. Window and door types

12. Install electrical rough-in (fans)
a. Ability to:
i. Resolve hazards
ii. Provide power to new equipment/appliance
iii. Install or repair circuit
iv. Install or repair lighting
v. Install or repair controls
vi. Seal penetrations and replace insulation
vii. Install systems, including photovoltaic

b. Knowledge of:
i. Appliance requirements
ii. Building codes
iii. Building science

iv. Circuitry
v. Clearances
vi. Efficiency
vii. Fire codes
viii. Local codes
ix. Manufacturer's specifications
x. Materials
xi. National Electrical Code
xii. Potential damage
xiii. Trade-specific knowledge
xiv. Wiring

13. Install plumbing
    a. Ability to:
        i. Remove old equipment
        ii. Resolve hazards
        iii. Provide hookups
        iv. Install or repair fixtures
        v. Install equipment including renewable systems
        vi. Seal penetrations and replace insulation
        vii. Check for draft
        viii. Install simple efficiency measures (low-flow fixtures, pipe wrap insulation)
        ix. Install advanced efficiency measures (hot water loop, on-demand water heaters)
    b. Knowledge of:
        i. Advanced plumbing
        ii. Asbestos
        iii. Basic carpentry
        iv. Combustion safety
        v. Brazing
        vi. Building codes
        vii. Building science
        viii. Combustible clearances
        ix. Domestic water heaters
        x. Drainage
        xi. Electrical

xii. Fuel gas code
xiii. Gas fitting
xiv. Gaskets
xv. Grading
xvi. Interior finish
xvii. Local hazards
xviii. Manufacturer's specifications
xix. Materials
xx. Pipe fitting
xxi. Pipe insulation
xxii. Piping
xxiii. Smooth wrench surfaces
xxiv. Tapes
xxv. Temperature requirements
xxvi. Venting
xxvii. Vermin hazards

14. Install roofing and flashing
    a. Ability to:
        i. Identify leak sources
        ii. Repair leak source
        iii. Remove roofing system
        iv. Install roofing system
        v. Insulate roof deck
        vi. Install attic venting
        vii. Flash new penetrations
    b. Knowledge of:
        i. Building science
        ii. Carpentry
        iii. Clearances
        iv. Debris control
        v. Drainage
        vi. Drainage plane
        vii. Fall protection
        viii. Fasteners
        ix. Flashing

x. Gravity
xi. Live load
xii. Local building codes
xiii. Manufacturer's specifications
xiv. Materials
xv. Math skills
xvi. Product installations
xvii. Roofing systems
xviii. Tools

15. Clean as you go (organize)
    a. Ability to:
        i. Return tools to central area
        ii. Pick up material drops
        iii. Return belongings
        iv. Clean work area
    b. Knowledge of:
        i. Disposable materials
        ii. Dust containment
        iii. EPA lead safety
        iv. MSDS
        v. Safety
        vi. Safety requirements
        vii. Solvents
        viii. Tool inventory
        ix. Tool safety
16. Address deviations from work scope
    a. Ability to:
        i. Identify deviation
        ii. Report deviation
        iii. Request direction to modified work scope
        iv. Implement modified work scope
    b. Knowledge of:
        i. Work scope

15.3.6 Wrap up

1. Pick up tools and materials

a. Ability to:
    i. Inventory tools and materials used
    ii. Clean tools and materials
    iii. Store tools and materials
    iv. Report lost or broken items
b. Knowledge of:
    i. Basic math skills
    ii. Manufacturer's specifications
    iii. Materials
    iv. Solvents
    v. Tool safety
    vi. Value of materials

2. Clean up an close out
    a. Ability to:
        i. Break down protective barriers
        ii. Pick up protective barriers
        iii. Contain hazardous materials
        iv. Contain and dispose of materials and waste
        v. Dust, vacuum, mop, scrub, rake
        vi. Restore occupant belongings
        vii. Participate in final walk through inside and outside, including restoring mechanical systems
        viii. Report to crew chief for final inspection
    b. Knowledge of:
        i. Disposal procedures
        ii. EPA lead safety
        iii. Hazardous materials
        iv. Local codes
        v. Local facilities
        vi. MSDS
        vii. Safe lifting practices
        viii. Safety procedures
        ix. Work scope
3. Participate in crew debriefing (post-weatherization job review)
    a. Ability to:
        i. Attend meeting

ii. Report awareness of deficient knowledge
iii. Report what when well and what went wrong
iv. Discuss homeowner concerns, complaints, and complements
v. Offer additional safety suggestions

b. Knowledge of:
i. Safety procedures
ii. Work scope

15.4 Final Inspector

A final inspector is an evaluator who verifies the work performed against the work plan, specifications and standards, performs building diagnostics, records/reports findings and concerns, and specifies corrective actions; by conducting a methodological audit/inspection of the building, performing safety and diagnostic tests, and by observing the retrofit work; in order to ensure the completion, appropriateness and quality of the work providing for the safety, comfort, and energy savings of the building occupants.

15.4.1 Conducting Final Inspections

1. Verify worker compliance with safety rules
   a. Ability to:
      i. Walk around the job site
      ii. Observe the workers
      iii. Observe the site conditions
      iv. Interview the crew chief or subcontractor
      v. Work in confined spaces
   b. Knowledge of:
      i. Basic construction
      ii. Codes and standards adopted by local jurisdiction
      iii. Relevant federal regulations (OSHA, EPA, DOE, etc.)
      iv. First aid
      v. Interview techniques
   c. Skill in:
      i. Communication
      ii. Observation techniques
2. Assure worker professionalism

a. Ability to:
    i. Conduct client interviews
    ii. Evaluate the job site (trash, cleanliness)
    iii. Verify that workers are familiar with their employer's code of conduct
    iv. Observe the behavior of the workers
b. Knowledge of:
    i. Awareness of the employer's requirements
    ii. Knowledge of positive reinforcement techniques
c. Skill in:
    i. Communication
    ii. Observation
    iii. Remaining tactful

3. Address work problems
    a. Ability to:
        i. Review the work against the work scope
        ii. Observe worker skills
        iii. Check materials being installed
        iv. Observe sequencing of the components installed
        v. Verify the condition and capacity of the equipment
        vi. Determine need to conduct diagnostic tests
        vii. Conduct diagnostic tests
        viii. Document process issues and missed opportunities for change orders
        ix. Revise work orders
        x. Redirect weatherization work
        xi. Discuss issues with crew chief
        xii. Demonstrate proper methods to installers
        xiii. Discuss missed opportunities with the energy auditor
    b. Knowledge of:
        i. Basic building science
        ii. Codes and standards adopted by local jurisdiction
        iii. Building materials
        iv. Construction tools and use
        v. Construction practices
        vi. Documentation procedures

vii. Installation methods
viii. Standards and specifications
ix. Test procedures
x. Diagnostic tests

c. Skill in:
i. Communication
ii. Diplomacy
iii. Observation
iv. Training

4. Evaluate client satisfaction regarding the in-process work
a. Ability to:
i. Interview the client
ii. Observe client behavior
iii. Document findings
iv. Communicate findings to the crew chief or other responsible parties

b. Knowledge of:
i. Interview techniques

c. Skill in:
i. Communication
ii. Observation

15.4.2 Conducting Final Inspections – Post-Work Visual/Sensory Inspections

1. Review client file and work scope
a. Ability to:
i. Review the energy audit report
ii. Review the work order
iii. Review the invoices or job completion report
iv. Review diagnostic test results provided by installers
v. Interpret diagnostic test results
vi. Interpret invoices
vii. Interpret work order
viii. Reconcile audit to work order to invoice

b. Knowledge of:
i. Program requirements

ii. Diagnostic procedures
iii. The energy audit process
iv. Job costing

2. Perform an exterior and interior visual/sensory inspection
   a. Ability to:
      i. Perform exterior and interior walk around inspection
      ii. Compare observations of exterior/interior to the client file information.
      iii. Verify installed components
      iv. Note any anomalies or missed opportunities or energy audit discrepancies
      v. Identify damage done by workers/subcontractors
      vi. Document non-compliance or exceptional work with camera
      vii. Identify additional building-specific diagnostic tests
   b. Knowledge of:
      i. Energy audit process
      ii. Basic building science
      iii. Building materials
      iv. Codes and standards adopted by local jurisdiction
      v. Construction work practices
      vi. Installation methods
      vii. Standards and specifications
      viii. Test protocols
      ix. Diagnostics tests
   c. Skill in:
      i. Analytical thinking
      ii. Basic math
      iii. Basic tool use
      iv. Observation
      v. Organization
3. Evaluate client satisfaction
   a. Ability to:
      i. Conduct client-specific interview to determine behavior changes, client education, comfort, satisfaction

ii. Conduct program-specific interview to determine worker performance, process, scheduling, value, opportunities for worker improvement
iii. Observe client behavior (thermostat setting, attire, window position, etc.)
iv. Document client feedback
v. Take corrective actions as necessary

b. Knowledge of:
i. Client education
ii. Installed components

c. Skill in:
i. Communication
ii. Listening
iii. Mediation
iv. Observation
v. Remaining tactful

4. Determine pass/fail of work
a. Ability to:
i. Review results of visual/sensory inspection
ii. Review results of diagnostic tests
iii. Make a pass/fail determination
iv. Obtain client signoff if passed
v. Report inspection approval if passed
vi. Identify work problems if failed
vii. Generate a punch list if failed

b. Knowledge of:
i. Basic building science
ii. Diagnostic thresholds
iii. Codes and standards adopted by local jurisdiction
iv. Standards and specifications

c. Skill in:
i. Making decisions
ii. Being accurate
iii. Analytical thinking
iv. Attention to detail
v. Remaining tactful

15.4.3 Conducting Final Inspections – Post-Work Diagnostic Inspections

1. Conduct health and safety tests
    a. Ability to:
        i. Perform combustion safety tests (heating systems, water heaters, ovens, stoves, fireplaces)
        ii. Perform ventilation system tests
        iii. Conduct moisture evaluations
        iv. Conduct electrical safety tests
    b. Knowledge of:
        i. Codes and standards adopted by local jurisdiction
        ii. Combustion safety protocols
        iii. First aid
        iv. Heating systems
        v. Moisture issues
        vi. Safety issues
    c. Skill in:
        i. Analytical thinking
2. Conduct diagnostic tests
    a. Ability to:
        i. Perform blower door tests
        ii. Perform pressure pan tests
        iii. Conduct zone pressure tests
        iv. Conduct temperature rise test on furnaces
        v. Conduct external static pressure test of furnaces
        vi. Perform fan flow tests
        vii. Perform infrared scans
        viii. Perform duct leakage tests
        ix. Perform appliance tests
        x. Conduct domestic water heater temperature tests
        xi. Record results of all tests
    b. Knowledge of:
        i. Basic building science
        ii. Diagnostic testing procedures
        iii. Manufacturer’s specifications
        iv. Program requirements

c. Skill in:
    i. Attention to detail

3. Identify work problems
    a. Ability to:
        i. Review the results of all tests
        ii. Compare results against field guide notes
        iii. Compare results against pre-test data
        iv. Compare results against work plan projections
        v. Identify missed opportunities
        vi. Determine deficiencies
        vii. Target deficiencies for corrective actions
        viii. Generate a punch list
        ix. Make decisions
        x. Read a flowchart
    b. Knowledge of:
        i. Basic building science
        ii. Field guides
        iii. Codes and standards adopted by local jurisdiction
        iv. Standards and specifications
        v. Testing protocols
    c. Skill in:
        i. Analytical thinking
        ii. Communication

15.4.4 Ensuring Worker Professionalism

1. Perform spot checks
    a. Ability to:
        i. Visit in-process job sites
        ii. Conduct random sampling of job-site documents
        iii. Conduct random sampling of worker credentials
        iv. Observe the workers
        v. Interview the client
        vi. Interview trade workers on job
        vii. Interview others at the job site
        viii. Ability to observe without interfering
    b. Knowledge of:

i. Credentialing requirements for workers
ii. Professional behavior and code of conduct
iii. Program and agency guidelines
iv. Required documentation

c. Skill in:
i. Attention to detail
ii. Communication
iii. Listening
iv. Observation
v. Remaining tactful

2. Provide feedback regarding professionalism
a. Ability to:
i. Document incidences of lack of professionalism
ii. Document positive incidences of professionalism
iii. Communicate with crew chief or appropriate part regarding professionalism incidences
iv. Assure client of corrective measures
v. Assist in training workers

b. Knowledge of:
i. Professional behavior and code of conduct
ii. Required documentation

c. Skill in:
i. Remaining impartial
ii. Communication

15.4.5 Ensuring Program Compliance

1. Maintain professional credentials
a. Ability to:
i. Continue education and training
ii. Maintain professional licenses and/or certifications
iii. Maintain memberships in professional organizations
iv. Participate in industry activities

b. Knowledge of:
i. Licensure and certification requirements

2. Confirm the allocation of public funds
a. Ability to:

i. Review work orders
ii. Flag instances where work completed does not match funding requirements
iii. Guard against cost overruns
iv. Report disallowed costs

b. Knowledge of:
i. Work scopes
ii. Allowable activities under funding sources
iii. Maximum allowable caps on funding sources

c. Skill in:
i. Analytical thinking
ii. Attention to detail

3. Evaluate installed measures against the Maine Weatherization Standards and State and local codes
a. Ability to:
i. Compare work completed with the accepted practices
ii. Identify work that does not meet accepted practices
iii. Determine if problem is material or labor related
iv. Suggest program changes
v. Recommend education for auditors and installers
vi. Aggregate information
vii. Identify gaps in training
viii. Clearly write a report

b. Knowledge of:
i. Basic building science
ii. Codes and standards adopted by local jurisdiction
iii. Industry standards
iv. Program requirements
v. Training curricula

c. Skill in:
i. Analytical thinking
ii. Remaining tactful

4. Close out the project
a. Ability to:
i. Ensure all punch-list items have been completed

ii. Assemble all required documentation (certificates, photos, etc.)
iii. Confirm all required signatures were obtained
iv. Prepare complete reports (checklists, required program reports, etc.)
v. Submit authorization for payments/reimbursements/invoices

b. Knowledge of:
i. Agency/program processes
ii. Program requirements
iii. Required paperwork
iv. Required signatures

c. Skill in:
i. Organization
ii. Report writing

5. Maintain files and records
a. Ability to:
i. Maintain job logs and notes in the files
ii. Maintain photos in the files
iii. Maintain information on any anomalies on the job
iv. Maintain information on any ongoing complaints
v. Maintain documentation from program monitoring (federal, state, utility)

b. Knowledge of:
i. Legal responsibilities
ii. Program requirements
iii. Recordkeeping practices

c. Skill in:
i. Attention to detail
ii. Organization

16 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 the Depressurization Tightness Limit (DTL).

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) – Room and enclosed air volume that contains a combustion appliance. 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 Appliance Zone (CAZ) – The closed space or area that holds one or more combustion appliances.

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 – 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.

General Heat Waste Measures – Weatherization measures for which savings or savings-to-investment ratios (SIR) are difficult or impossible to calculate. Examples include all air sealing work, ductwork sealing and insulation, pipe insulation, and dryer vent kit installation. No SIR values are required for these measures.

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 to 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.

HWAP – Home Weatherization Assistance Program.

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.

MSDS – Materials Safety Data Sheet.

- 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.

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.

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 manufactured homes assembled on the site from pieces shipped to the site on flatbed trucks. Does not include manufactured homes and double-wides.

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 or 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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