

Maine Weatherization Standards

Low-Income Weatherization
Assistance Program
January 2005



State of Maine
Maine State Housing Authority
Division of Energy and Housing
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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 the state. The success of this program depends upon agencies and contractors having a full understanding of the State's 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 manual delineates material specifications as well as the steps that should be followed to complete each measure. Alternative methods will continue to 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 for doing so. It is understood by the Maine State Housing Authority (MSHA), Energy & Housing Services Division (EHS) 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 almost 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.

From time to time, these Standards may be amended and/or revised by the MSHA, 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. In this sense, they will never be complete. In preparing this edition, some topics were almost certainly overlooked. The Standards will become more complete and comprehensive with use as omissions are identified and new topics are addressed with new policy or guidance.

1000 Administrative, Scope, and General Requirements

1100 Effective Date

1. All weatherization measures performed or completed on or after the date specified in the Subgrant Agreement shall comply with these Standards.
2. All dwelling units completed after the effective date shall comply with these standards.

1200 Scope

1. The goal for the Maine State Housing Authority's (MSHA) 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 allowed 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 Maine State Housing Authority's (MSHA) Energy & Housing Services Division (EHS).

1300 Enforcement

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

1400 Amendments to Program Field Standards

1. From time to time, these Standards may be amended and/or revised by the Maine State Housing Authority's (MSHA) 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. The process for implementation of change will be either by recommendation of Maine State Housing Authority (MSHA) technical staff to MSHA'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 MSHA, Director of the EHS; followed by
 - c. Adoption by MSHA 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 provided to the Housing Directors of all agencies at least thirty days prior to implementation to allow the opportunity for review and comment. The Housing Directors may then submit written comments regarding the changes to the Director of EHS for review and consideration. The Director of EHS will respond to all comments received prior to implementation of proposed changes.

2000 Energy Audit Requirements

2100 Program Energy Auditor Certification

There are two stages of energy auditor certification within the Maine low-income weatherization program. The first stage – State of Maine Energy Auditor 1 certification – is allowed by Maine law (Title 35-A, *Training for Energy Auditors*). These requirements are defined below in Section 2110. MSHA has designated this first stage – State of Maine Energy Auditor 1 certification – as a requirement for energy auditors working within the Maine Low-Income Weatherization Program.

The second stage – Senior Auditor certification – is also required by MSHA. The requirements for Senior Auditor certification and the responsibilities and privileges associated with this title are defined below in Section 2120.

2110 Energy Auditor Training, State of Maine Auditor 1¹

1. Auditor Training

- a. “To the extent that funds and resources allow, the [Maine Public Utilities Commission (PUC)] shall establish voluntary training programs for energy auditors that most effectively meet the needs of the public. For the purpose of this subsection, an energy auditor is a person who is trained to prepare a report that delineates the energy consumption characteristics of a building, identifies appropriate energy efficiency operations and maintenance procedures and recommends appropriate energy efficiency measures. The [PUC]:”
 - i. May develop separate programs for audits of different building types and functions when the [PUC] determines that the skills or training needed to perform these audits merit the distinction;
 - ii. Shall determine the content of the training, the hours required for the course completion and the manner in which applicants must demonstrate proficiency in energy auditing;
 - iii. Shall issue a certificate of completion to individuals who meet the requirements the [PUC] has established;
 - iv. May establish reasonable course fees. All fees must be paid to the Treasurer of State to be used by the [PUC] for the purposes of this [activity];
 - v. Shall determine terms for the expiration and renewal of an applicant’s certificate of completion; and

¹ This section is based on Maine Statute Title 35-A, § 10003, *Training for Energy Auditors*, updated through 121st First Regular Legislative Session.

- vi. Shall determine an appropriate means of maintaining recognition of the training received by persons holding a certificate issued pursuant to former Title 32, chapter 88.”

2120 Senior Energy Auditor Certification

1. As of April 1, 2004, it is required by MSHA that:
 - a. All persons auditing homes in the Maine Weatherization Assistance Program (WAP) obtain a State of Maine Auditor 1 certification within six (6) months of hire.
 - b. All persons inspecting homes in the Maine WAP obtain a Senior Auditor certificate within eighteen (18) months of hire.
 - c. Persons working in the Maine WAP holding neither a State of Maine Auditor 1 certification nor a Senior Auditor certificate may perform WAP client home audits only in the presence of a person holding either a State of Maine Auditor 1 certificate or a Senior Auditor certificate.
 - d. Persons working in the Maine WAP holding a State of Maine Auditor 1 certificate but not a Senior Auditor certificate may perform WAP client home audits without supervision.
 - e. Persons working in the Maine WAP holding a State of Maine Auditor 1 certificate but not a Senior Auditor certificate may perform WAP client home final inspections only in the presence of a person holding a Senior Auditor certificate.
 - f. Exemptions to any and all of these requirements may be granted by MSHA on a case-by-case basis in response to written request.
2. Process:
 - a. The Maine State Housing Authority (MSHA) will form an independent standing committee consisting of five (5) members and two (2) alternates. Membership will be as follows: one from the membership of the Maine Community Action Housing Council, one from the weatherization staff of the state agency administering the Maine Weatherization Program (MSHA) and three from the pool of holders of Senior Auditor Certificates.
 - b. Said committee will meet on an as-needed basis to examine candidates for the Senior Auditor certificate and/or conduct other appropriate business. A quorum will consist of three (3) members. One of the quorum must be the MSHA staff member.
 - c. Alternates must be holders of Senior Auditor Certificates.
 - d. The MSHA may hire such other disinterested third parties as it deems necessary to assist with the examination and scoring process.
 - e. Candidates may apply to be examined for a Senior Auditor certificate when:

- i. The candidate has earned a State of Maine Auditor 1 certificate.
 - ii. The candidate and the Senior Auditor, under which (s)he is training, agree that (s)he is properly prepared.
- f. When sufficient candidates apply for the exam, the standing committee will designate a scoring team to:
 - i. Select and audit a dwelling, create a consensus audit report and make the dwelling available to Senior Auditor certificate candidates for audits.
 - ii. Supervise the candidate audit process.
 - iii. Compare the candidate's audit report to the committee's audit report.
 - iv. Score the candidate's audit report.
- g. Scoring of candidates for the Senior Auditor certificate will be done by means of the tool used in the 2003 Senior Auditor certification process and will include the audit process and the submitted work order. The scoring tool may be modified as necessary from time to time by agreement between the standing committee and the MSHA.
- h. Scoring will be by consensus of the scoring committee. Seventy five percent will constitute a passing score. The quorum for scoring will be three scoring team members. One of the quorum must be the MSHA Weatherization Program staff member.
- i. At no time will a standing committee member participate in the evaluation or scoring of a Senior Auditor certificate candidate employed by the same Community Action Agency (CAA) as the standing committee member.
- j. In the case of a candidate achieving a score of seventy five percent or more, the standing committee will issue a recommendation to the MSHA that a Senior Auditor certificate be granted to the candidate.
- k. On receipt of the standing committee recommendation, the MSHA will issue a certificate to the candidate granting the authority to audit and inspect all types of homes retrofitted under the Maine Weatherization Program. The certificate will be valid as long as the holder:
 - i. Regularly attends MSHA-sanctioned WAP conferences and trainings.
 - ii. Remains in good standing in the professional WAP auditing community.
- l. The MSHA, alone or acting in conjunction with the standing committee, may revoke a Senior Auditor certificate if the holder:

- i. Fails to regularly attend MSHA-sanctioned training(s) or conferences.
 - ii. Is consistently unable to demonstrate such skills as are commonly attributed to the weatherization auditing profession.
 - m. The MSHA will cover all expenses for the Senior Auditor Evaluation process including, but not limited to, standing committee member travel, audit building rental, preparation, etc.
 - n. There will be no charge of any sort for either the exam process or the certificate itself to the candidates for Senior Auditor certification who are employed in the Maine WAP except that persons failing the exam three or more times in a three-year period may be required to reimburse MSHA for the expenses arising from any further attempts.
 - o. Persons not employed in the Maine WAP may request to be examined for a Senior Auditor certificate by applying to the standing committee. Fees may apply.
 - p. The Building Technology Committee (BTC), a sub-committee of the Maine Community Action Housing Council, will periodically review the standards that define the skills required to qualify for a Senior Auditor certificate. If at any time the BTC, acting in conjunction with MSHA, determines that the industry standards have significantly surpassed those under which the majority of existing Senior Auditor certificates were originally issued, the BTC may recommend that the MSHA call for a general re-certification of all Senior Auditor certificate holders.
 - q. The MSHA will make every effort to assist those CAAs having no Senior Auditor certificate holder on staff. Assistance options may include but are not limited to:
 - iii. Authorizing the temporary hire of a certified Senior Auditor under either Peer or Professional Mentoring.
 - iv. Having the MSHA Weatherization Field Examiner provide Senior Auditor services directly to the CAA.
3. Grievance Policy:
- a. Persons or organizations aggrieved in any way by this system or its functioning may appeal in writing to the standing committee.
 - b. The standing committee will review and act upon the grievance within sixty (60) days, responding in writing to the aggrieved party.
 - c. Further redress may be obtained by appealing the standing committee ruling to the Maine State Housing Authority.

2200 Energy Audit Requirements

2210 General Energy Audit Requirements

1. The Permission Form must be filled in by the auditor, explained to the client by the auditor, and signed by the client and the auditor.
2. The Maine Energy Audit Field Form (MEAFF) must be completed by the auditor. See Section 2220, below.
3. The Computerized Energy Audit (MEADOW), Maine's waiver audit, must be completed by the auditor. See Section 2230 below.
4. A work order must be completed for the job by the auditor. See Section 2240 below.
5. The 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.

2220 Maine Energy Audit Field Form (MEAFF)

1. An energy audit of each unit must be conducted and documented in the client file.
2. All shaded boxes on the MEAFF form must be filled in with the correct information for the job. If a box cannot be filled in with the correct information, a written reason must be given.
3. Using the MEAFF form, the energy audit must include:
 - a. The client and job identification;
 - b. An energy index calculation in units of Btu/ft², heating degree day;
 - c. An indoor air quality and moisture assessment;
 - d. Results of pre- and post-weatherization blower door tests;
 - e. A Building Tightness Limit (BTL_a) calculation to ensure compliance with ASHRAE 62-2001;
 - f. An inventory of combustion appliances;
 - g. Record of the post-weatherization worst-case draft test;
 - h. An insulation assessment, including existing and recommended insulation levels for all appropriate thermal boundaries;
 - i. The results of zone pressure diagnostics testing, if appropriate;
 - j. A ductwork assessment, if appropriate;
 - k. Results of pressure pan testing, for mobile homes.
 - l. Results of refrigerator metering and the cost effectiveness of replacement, if appropriate;
 - m. A general baseload audit that includes an inventory of electrical appliances and 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 boundary 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 boundary 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, and
 - b. Increasing the insulating value of thermal boundary surfaces, when appropriate.
 - c. Health and safety.

2230 Computerized Energy Audit (MEADOW)

- 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 SIR calculation.
- 2. Values and methods used for the MEADOW computerized 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 at least the manufacturer's recommended minimum installation density.
 - b. The Building Technology Committee (BTC), made up of energy auditors from all the State agencies, will recommend to the appropriate organization (either the Housing Council or MSHA) changes each year to:
 - i. The typical service life of each energy-saving measure. The service life values must be discounted for use in the calculation of SIRs in accordance with Department of Energy guidelines.
 - ii. The method for determining the cost of fuels that is used in the MEADOW audit.

iii. Maximum insulation levels.

2240 Work Order Requirements

1. Each client file must have an accurate work order generated by the State-approved computerized audit.
 - a. *Exception:* In the case of multi-family units – those which the State-approved audit does not address, such as high-rise units 3 stories or greater, units with large central heating systems, or units with large common areas – agencies and contractors must work in consultation with the MSHA in the development of appropriate priority lists.
2. 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.
 - a. Measures for which SIR values are less than 1.00 are ineligible.
 - b. 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.
 - c. If, because of a budget constraint or other valid reason, all measures having an SIR of one or greater are not installed, a written explanation must be included in the job file.
 - d. It is not permissible to omit measures vital to the success of the weatherization job. For example, it shall not be permissible to partially insulate a dwelling because of budget constraints.
3. If the estimator is aware of more than one method of installing an energy conserving measure, he must be able to justify, in writing in the client file, the selection of a method that does not have the highest SIR of the possible methods.
4. The work order must clearly itemize the work to be completed by the agency crew or contractor. The work order must:
 - a. Be well organized and legible.
 - b. Include all appropriate dimensions and quantities.
 - c. Include any appropriate special instructions for necessary inspections or unusual installations.
 - d. The method of installation with the proposed amount, type, and R-value of the insulation to be installed.
 - e. The flammability of the insulation.
 - f. The type of vapor barrier and ventilation to be installed.
 - g. The name, the principals, and business mailing address of the firm providing and installing the insulation.

- h. Details of any warranties on materials used in the home.
- i. A description of the guarantee on settling, including anticipated amount and time frame of settling.
- j. A written description of any work required for the installation of the insulation, including who will do the work and who will pay for it.

2250 Equipment Maintenance

1. All test equipment used for diagnostics, evaluation, and installation of measures shall be maintained according to the manufacturer's recommendations. 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 blowing machines including their motors, hoses, seals, and filters.
2. Agencies should develop and adhere to an equipment maintenance schedule for equipment used by energy auditors.
3. Contractors should develop and adhere to an equipment maintenance schedule for equipment used for weatherization program work.

3000 Health and Safety Requirements

3100 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 well being 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 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 result in a monetary savings. Therefore, as part of the Maine Weatherization Assistance Program, the following health and safety standards have been developed 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.

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 have an energy-savings characteristic 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 Weatherization Reporting Form.

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, crew, or subcontractor 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 the crew or contractor's health and safety, the Maine Weatherization Assistance Program allows *technical waivers* for any audit or inspection process, installation, or any portion of the weatherization activity.

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

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. Unsafe and excessive levels of chipping and peeling lead paint in pre-1978 homes. This is of particular concern on interior surfaces and components.
 - e. Mold or mildew.
2. Air quality assessment, including:
 - a. Interviewing client(s) regarding health conditions of occupants with the intent of determining if air quality is unacceptable.
 - b. Determination of ventilation needs for ensuring acceptable indoor air quality. Any mechanical ventilation requirements shall be based on *Standard for Acceptable Indoor Air Quality*, ASHRAE Standard 62-2001.
3. Combustion systems assessment, including:
 - a. Worst-case draft test in appropriate dwellings after all weatherization work has been completed.
 - b. Fuel storage hazards, including oil tank or propane storage problems.
 - c. Hazardous combustion appliance conditions.
4. Assessment of crew, 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 weatherization personnel trained in Maine certified lead-safe work practices.

3200 Worker Health and Safety

1. It is the responsibility of the agency and/or the entity performing the 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.
3. Weatherization services must be provided in a manner that minimizes risk to weatherization personnel.

3300 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 or the client's exposure to a hazard, work on the dwelling may have to be stopped.

The MSHA expects the crews, contractors, and auditors 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 agencies, crews, auditors, and general contractors involved in weatherization work.

3310 Workplace Safety Guidelines

1. It shall be the responsibility of the weatherization agency to initiate and maintain such programs as may be necessary to comply with this part.
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 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 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 health or safety hazard, the occupants will be asked to leave during the work activities.

MSHA will allow technical waivers for non-performance of audits, installations, and/or inspections, or any portion of these functions, if such action will expose weatherization personnel to conditions regarded as unsafe or unhealthy according to OSHA Construction Industry Standards.

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 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 per 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 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 to protect worker health or safety.
- 4. Agencies and contractors should have in place a tool safety program designed to protect workers from workplace hazards. This program should ensure that:
 - 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 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 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.
2. Agencies shall establish a policy to train their employees in lead-safe work practices and to ensure contractor employees are trained in lead-safe work practices.

3320 Required Postponement of Service Policy

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 must develop an approved policy which, when implemented, allows weatherization staff to postpone services when certain conditions or circumstances exist. At a minimum, the agency/contractor postponement-of-service policy shall contain the elements listed below.

1. *Postponement 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 the crew or contractor.

- f. A mobile 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 the EHS of MSHA 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 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
 - v. Unvented combustion appliances.
- 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 weatherization work 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 and life-threatening disease.

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.

2. Procedure

- a. If an agency or contractor cannot, or chooses not, to weatherize a dwelling unit, it must notify the client or owner/authorized agent by use of the Postponement 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 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); and
 - v. The right of appeal.
- b. All documentation justifying the decision to postpone services must be kept in the client file.

3330 Asbestos Inspection Procedures

- 1. Prior to performing 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 weatherization work where asbestos is present shall be based on the judgment of the most qualified individual available to the agency or contractor.
- 3. 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.
- 4. All agency and contractor personnel must wear high quality respirators any time they are working with or near asbestos materials.
- 5. Materials containing asbestos may not be cut, drilled, or disturbed in any manner that may cause asbestos fibers to become airborne.

6. Agencies and contractors may not use abatement contractors to remove or dispose of asbestos-containing materials without prior authorization from the MSHA.

3340 Lead-Based Paint Procedures

On July 12, 2002, The Department of Energy (DOE) issued Weatherization Program Notice 02-6. This notice requires the states and its subgrantee to consider and implement health and safety measures associated with lead-based paint when performing weatherization work in pre-1978 homes. DOE's policy is that Weatherization personnel must be aware of the hazard and conduct weatherization activities in a safe manner to avoid contaminating homes with lead-based paint dust and debris, and to avoid exposing the clients, themselves, and their families to this hazard. The DOE has required that all weatherization personnel performing work in a pre-1978 home be trained in lead-safe work practices.

1. Lead-safe work practices must be implemented by local weatherization agencies and contractors when:
 - a. The dwelling was constructed prior to January 1, 1978, and
 - b. The dwelling has not been determined to be lead-based paint free, and
 - c. Either the amount of disturbed lead-based painted surface exceeds 2 square feet per room of interior surface, twenty square feet of exterior surface, or 10 percent of a small component type, e.g. window; or the amount of lead-based paint dust that will be generated by the weatherization work exceeds the OSHA-defined airborne levels for lead.
2. Local weatherization agencies and contractors need to consider the following when performing work in a pre-1978 home.
 - a. Is the agency or contractor prepared to work in a pre-1978 home (i.e., are they trained in lead-safe work practices)?
 - b. What is the condition of the painted surfaces in the house (i.e. are there excessive amounts of chipping and peeling paint that would make clean-up very difficult)?
 - c. Will the weatherization work cause substantial paint chip and dust debris rendering the work site unsafe for clients and weatherization personnel?
3. Based on the factors above, the local weatherization agency or contractor needs to determine whether to:
 - a. Proceed with all the weatherization work following lead-safe work practices; or
 - b. Do some of the weatherization tasks and defer others that are considered more risky; or

- c. Defer all weatherization work until lead-based paint hazards can be remedied through another program.
- 4. It is DOE's policy that local weatherization agencies and their contractors obtain and carry Pollution Liability Insurance (POI) to cover claims of lead-based paint poisoning due to weatherization activities.

3350 Client Health and Safety

- 1. Weatherization services must be provided in a manner that minimizes risk to clients.
- 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.
- 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.
- 4. Building owners and clients must be notified of any health or safety problems that require weatherization work to be postponed or terminated. Documentation of this notification must be included in the job 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, during the weatherization process.
- 7. The installation of hazardous materials must be performed in well-ventilated areas.
- 8. Weatherization personnel shall not smoke cigarettes, cigars, or pipes in a client's 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 would reduce the natural air leakage of the dwelling.
- 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. Hazardous levels of carbon monoxide.
- b. Leaks in waste plumbing pipes of standing raw sewage.
- c. Hazardous levels of mold.
- d. Mercury spills.
- e. Friable asbestos in an area that children frequent.

3360 Moisture Remediation, Assessment, and Repairs

3361 Remediation of Mold

The use of DOE funds for the removal of mold and other related biological substances is not an allowable weatherization expense. 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. However, in specific situations approved by MSHA, DOE funds may be used if the related problems must be remedied to allow effective weatherization work.

If any existing mold or mildew problems are beyond the scope of the weatherization program, the weatherization work must be postponed 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 mold condition. Use the Postponement of Services form to clearly delineate the perceived problem and indicate who will be responsible for its remedy. The Postponement of Services form must be reviewed and signed by the client and/or landlord.

3362 Assessment of Moisture Conditions

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

1. The moisture assessment section of the Maine Energy Auditor Field Form (MEAFF) 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.
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 cost-effectively remove the moisture. In some cases, air sealing must be done in order to reduce the source of the moisture (i.e., sealing off crawl spaces from the house, or sealing attic leakage to eliminate condensation on the roof deck).
4. Because air tightening may cause an increase in relative humidity, 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 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.
6. If a dwelling has a CFM₅₀ greater than the Building Tightness Limit (BTL), it should be assumed that there are still potential moisture problems. Moisture problems can sometimes occur in loose houses.

3363 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.

1. Moisture problems can be reduced or eliminated by controlling the source of the moisture. This can 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, and 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 3380 on page 25 for exhaust fan installation guidelines.

3364 Dryer Vents

1. Electric and gas dryers must always be vented to the outdoors.

2. Mobile home dryer vents must be extended through the skirting to the outdoors.
3. Dryer vent ductwork should be smooth-surfaced. No more than two 90° elbows may be used in the vent system, and ductwork should not exceed 15 feet. If three 90° elbows are required, the total length of the vent may not exceed 10 feet. Dryers may need to be considered to meet these limitations.
4. Flexible vinyl vent pipe shall not be used.
5. Flexible metal vent pipe may be used if it does 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).

3370 Building Tightness Limits (BTL)

The building BTL value shall be recorded on the MEAFF and placed in the client file. The calculated Building Tightness Limit value for the dwelling must be based on the ASHRAE 62 requirements of 15 CFM per person and at least 0.35 air changes per hour. Refer to page 109 for Building Tightness Limit calculation guidelines and use.

3380 Ventilation Systems for Acceptable Indoor Air Quality

3381 New Systems, Intermittent Operation

1. Exhaust fans that are intended for intermittent operation include kitchen and bathroom exhaust fans in dwellings that may or may not be tighter than the calculated Building Tightness Limit. These fans are intended for occasional use during cooking, baking, showering, and other times when moisture and odors are created by household activities.
2. High quality exhaust fans shall be used that have a sone level of 1.5 or less, are energy efficient and have an appropriate CFM rating.
3. Exhaust system ductwork shall consist of galvanized metal, rigid aluminum, PVC or metal flex duct under 6 feet in length. Vinyl flex duct shall not be used.
4. Exhaust system ductwork shall be extended through the roof or sidewall to the outdoors and the duct shall be insulated where it passes through an unconditioned area.
5. For intermittently operated exhaust fans, controls may be by a push-button switch timer, a separate on/off wall switch, an occupancy sensor switch, or hard wiring with a primary light switch (such as in a bathroom). Controls should be installed in the same room as the fan.

3382 New Systems, Continuous Operation

1. Ventilation systems are recommended in dwellings that are tighter than the calculated Building Tightness Limit (see page 109) or have a pre-existing moisture problem or other indoor air quality problem that cannot be corrected by any other means.
2. Ventilation systems are allowed in units that will receive substantial reductions in air leakage and, as a result, may develop moisture problems. Exhaust fans installed for these reasons shall be operated continuously when the dwelling is closed up to the outdoor air during winter mechanical heating or summer mechanical cooling.
3. To properly size fans for dwellings that are tighter than the calculated Building Tightness Limit, refer to page 109, Building Tightness Limit Procedures and Calculation.
4. High quality exhaust fans shall be used that are rated for continuous use, have a sone level of 1.5 or less, are energy efficient, and have an appropriately sized CFM rate.
5. Exhaust system ductwork shall consist of galvanized metal, rigid aluminum, PVC, or metal flex duct. The duct shall not exceed a maximum length recommended by the manufacturer. Vinyl flex duct shall not be used.
6. Exhaust system ductwork shall be extended through the roof or sidewall to the outdoors, and the duct shall be insulated where it passes through an unconditioned area.
7. For continuously operated exhaust fans, controls may be by a push button switch, a separate on/off wall switch, or hard wiring with a remotely located switch. Controls may be installed in the same room as the fan.
8. Fans should be located in a central hallway, kitchen, or bathroom.
9. When installing a continuously operating exhaust fan, educating the client about its use is extremely important. The client should be informed about:
 - a. The purpose(s) of the exhaust fan installation.
 - b. The importance of operating the fan whenever the house is closed up, such as during the heating season.
 - c. The disadvantages of not operating the exhaust fan.

3383 Existing Exhaust Fans

1. Existing mechanical exhaust ventilation systems should be made to terminate outside the building shell by extending the ventilation duct through the roof or sidewall.
2. Replacement exhaust system ductwork shall consist of galvanized metal, rigid aluminum, PVC, or aluminum flex duct under 6 feet in

length, with the duct insulated where it passes through an unconditioned area.

3384 ASHRAE Standard 62.2

1. Ventilation and other indoor air quality measures may be based on *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings* (ASHRAE Standard 62.2-2004) instead of *Standard for Acceptable Indoor Air Quality* (ASHRAE Standard 62-2001).

3400 Carbon Monoxide

3410 Measurement of Carbon Monoxide

1. The energy auditor's right to measure carbon monoxide (CO) emissions in combustion appliance vent connectors is restricted in Maine. However, auditors may measure the ambient levels of CO whenever they think it is prudent to do so.
2. CO emissions may *not* be measured:
 - a. In the vent connectors of oil-fired appliances.
 - b. In the vent connectors of gas-fired furnaces or boilers.
3. CO emissions may be measured:
 - a. 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.²
 - b. In 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.
 - c. Ambient CO may 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 are higher than 9 ppm, action to repair or replace the appliance must be taken.
4. CO emissions *must* be measured:
 - a. In atmospheric gas-fired water heaters as long as the probe for the measuring instrument is inserted just below the draft hood without drilling a hole in the vent connector. All gas-fired direct-

² For an acceptable protocol for metered testing of carbon monoxide emissions in the field, see www.karg.com/rangeprotocol.htm.

vent (sealed combustion) and atmospheric combustion water heaters must be tested for carbon monoxide emissions. If the measured CO levels are higher than 50 ppm as-measured or 100 ppm air-free, action to repair or replace the appliance must be taken.

5. MSHA views any ambient CO as potentially hazardous.
6. If ambient CO is discovered, the source of the CO must be found and corrected before any weatherization measures are installed.

3420 Carbon Monoxide Alarms

1. When a dwelling has any combustion appliances, at least one carbon monoxide (CO) alarm must be installed in the client 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, such as the CO-Experts UL-1B.
3. Preferred CO alarm is manufactured by Pro-Tech, model 7035 (available from EnTech Supply, 1-800-221-4785), which complies with the latest UL Standard 2034, or G.E. Kerr Companies, model CO-Experts UL-1B (available from G.E. Kerr Companies, 1-800-643-5377), which alarms at a lower carbon monoxide level than UL Standard.

3500 Unvented Space Heaters

1. A dwelling utilizing an unvented space heater cannot be weatherized.
2. In such cases, the Postponement of Services Form must be signed by the client.
3. The energy auditor must explain the consequences of using an unvented space heater to the client.
4. When the client has agreed in writing that they understand the policy and will not use the unvented space heater, weatherization may commence.

3600 Exceptions

1. 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.
2. 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.

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. Documentation in the MEAFF is required regarding any of the above exceptions.

4000 Client Education

4100 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 next.
 - b. During the initial field audit, education should cover:
 - i. What the client should expect during the energy audit.
 - ii. Air leaks discovered with the blower door.
 - iii. An explanation of any appropriate health and safety issues, such as:
 1. Lead paint.
 2. Asbestos.
 3. Combustion venting.
 4. Carbon monoxide.
 5. Mold and mildew.
 6. Plumbing leaks.
 7. Animal hazards such as rodent feces or insect infestations.
 8. Other possible hazards.
 9. 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.
 - iv. An explanation of energy conserving measures that will be installed.
 1. Air sealing.
 2. Addition of insulation.
 3. Heating system improvements.
 4. Water heater improvements.
 5. Baseload measures.
 - v. Improvements in thermal comfort in the dwelling as a result of the weatherization.

- vi. Explanation of gas range safety and use. Refer to Section 12800 on page 123.
 - vii. An explanation of required maintenance for existing equipment, added equipment, or energy-saving measures.
 - viii. What will take place after the energy audit:
 - 1. Schedule of events.
 - 2. Who will contact client next.
 - 3. When the work will be complete.
 - 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, if feasible. Such opportunities may include explaining how and why a measure is being installed and how the measure will enhance the client's energy bill and comfort.
 - 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.
- 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 is encouraged for client education, but demonstration has proven to work better in most cases.

5000 Air Sealing

5100 Air Sealing Requirements

Before air leakage reduction measures are installed, the 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 CFM₅₀ value. This should be done at least two or three 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.

The infrared scanning device is a powerful tool for finding air leaks when used in conjunction with a blower door. Energy auditors and weatherization crews and contractors are advised to use infrared scanning whenever the equipment is available and the use is practical.³

5200 Blower Door Guided Air Sealing

5210 Gross and Guided Air Sealing

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. Do not forget to check for leaks in a conditioned basement. If inspecting for leakage in an attic, it is best to pressurize the dwelling with the blower door by using the blower door fan reversal switch. This type of air sealing work is usually cost-effective only up to a point. Once that point is reached, air-sealing work should cease.

³ MSHA has an infrared camera that may be borrowed by agency energy auditors for weatherization analysis.

5220 Blower Door Use Requirements

1. Pre- and post-weatherization CFM₅₀ measurements must be completed on each unit and documented in each client file. A one-point CFM₅₀ blower door measurement is preferred over the multi-point computer-derived method. See Section 12100, page 105 for proper blower door setup and use.
 - a. Pre- and post-weatherization blower door tests may be waived due to the following circumstances:
 - i. 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 if a blower door test will be required.
 - iii. Suspected friable asbestos-containing material may be significantly disturbed.
 - iv. Other documented extenuating circumstances.
2. Blower door testing should continue during air-leakage reduction work as part of blower-door-guided air sealing.

5230 Cost-Effective Air Sealing Guidelines

1. 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 dwellings).
 - b. Chases around masonry and metal chimneys.
 - c. Chases around plumbing stacks.
 - d. Missing window sashes or lights.
 - e. Window sashes without locks.
 - i. Such sashes should be tightened by installing sash locks on double- and single-hung windows. Two cam-type locks per window sash are preferred.
 - f. Doors that are misaligned in their frames.
 - g. Missing drywall or other interior finish materials.
 - h. Missing or misaligned attic doors or hatches.
 - i. Missing or misaligned outside access doors in basements.
 - j. Other obvious holes or leaks in the dwelling envelope that:
 - i. Are cost-effective to seal,
 - ii. If filled, will protect the structure from damage, or

- iii. Are necessary for the proper installation of insulation.
2. Whenever feasible and more cost-effective, the installation of tube-filled, high density cellulose insulation in sidewalls, cathedral ceilings, convective bypass areas, open top plates/drop ceilings and other air leakage locations is preferred over the use of air sealing techniques using air barrier materials for achieving reductions in air leakage.

5300 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 draft test is performed. Please refer to Section 12430 on page 114 for detailed instructions.

5400 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 dwellings).
 - b. Chases around masonry and metal chimneys.
 - c. Chases around plumbing stacks.
 - d. Missing window sashes or lights.
 - e. Doors that are 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 an "IC" fixture.
4. Firestopping 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."⁴ Such material must be used to seal gaps or

⁴ NFPA 211 *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*, 2000 ed., 4-16.

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 of air around a chimney, a block 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, document this fact in the client file and include photographs.

5410 Penetrations in Basement Ceilings

1. If the basement is defined as an unconditioned zone, seal all significant leaks in the basement ceiling. If the basement ceiling will be insulated, make sure the penetrations are sealed before insulating.
 - a. Use the blower door to help find leaks in the ceiling by pressurizing the house, closing the door to the basement, and opening a basement window or door to the outside.
 - b. Sealing penetrations between a conditioned (the first-floor area) and an unconditioned space (the basement) is allowable and saves energy.
2. If the basement is defined as a conditioned zone, 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.
 - a. Insulate the house walls. The walls must be dense packed with cellulose unless conditions will not permit.

- b. After completing the attic air sealing and the attic and wall insulation installation, depressurize the dwelling with the blower door.
- c. With the blower door running, the door to the basement open, and the basement 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, this air is circuitously leaking in from the outdoors. Possible examples of these leaks include:
 - i. Chimney chases.
 - ii. Plumbing stacks.
 - iii. Interior walls open to the basement.
- d. 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.
- e. If penetrations are not leaking, do not seal them.

5420 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.
2. Covers for whole house fans should be easy to remove and reinstall.

5430 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.

5500 Zone Pressure Diagnostics

1. Zone Pressure Diagnostics (ZPD) testing to assist in the determination of the location thermal boundaries of the unit and the effectiveness of air sealing measures is highly recommended in some dwellings. Please refer to Section 12700 on page 120 for the details of ZPD procedures.

5600 Duct Leakage

5610 Introduction

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 envelope of the building or 2) in ducts that vent to the outdoors.

Leakage to or from the outdoors wastes more energy than leakage within the confines of the thermal envelope. Mobile 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 draft test (refer to page 114).

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

5620 Duct Leakage Standards

5621 Site-Built Homes, Including Manufactured Housing

1. MSHA recommends testing before weatherizing to determine whether the furnace air handler affects the pressure in the combustion appliance zone (CAZ).
 - 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 installed effectively.
 - i. Demonstrate the effectiveness of this weatherization work by performing a house-to-zone pressure and flow test (if

- possible) before and after converting the unconditioned space to a conditioned space.
- ii. Always repair disconnected ducts.
- iii. Sealing the shell of the space rather than the duct joints is preferred.
- 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. Perform a house-to-zone pressure and flow test (zone pressure diagnostics) to determine if the space in question is conditioned in terms of its pressure boundaries. The house-to-zone pressure should be 20 Pascals or less.
 - b. Visually inspect the conditioned space to ensure that the shell is properly air sealed and insulated.
 - c. If it is determined that weatherization work should be done to the shell 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 shell of the space rather than the duct joints is preferred.
 - iii. Goal: The house-to-zone pressure should be 20 Pascals or less.
 - d. There are a number of techniques that can be used to help find hidden leaks in ductwork. These methods 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.

5622 Manufactured Housing

1. If there is a belly return system in the mobile home or double-wide, convert it to a living space return system (refer to Section 8520 on page 72).
2. For a living space return system, the preferred duct leakage rate is zero, as the sum of the pressure pan readings while a blower door is depressurizing the dwelling to -50 Pascals.
3. For a living space return system, a sum of 3 Pascals for the pressure pan readings is acceptable if:
 - a. The floor boots are sealed with mastic, fiber tape, and metal, as necessary; and
 - b. The end of the supply trunk ducts is sealed.
 - c. Goal: Attempt to reduce the sum of the pressure pan readings to 0 Pascals.
4. For a living space return system, a sum of 5 Pascals for the pressure pan readings is acceptable if:
 - a. The floor boots are sealed with mastic, as necessary;
 - b. The end of the supply trunk ducts are sealed;
 - c. Any crossover ducts are visually inspected, repaired and sealed, as necessary (make sure these ducts are supported properly); 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 0 and 3 Pascals.
5. 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.

6000 Insulation Requirements

Cellulose insulation from most manufacturers is available in at least two grades that are characterized by the fire retardant added to the insulation. The fire retardants are usually 1) a mix of ammonium sulfate and boric acid or 2) boric acid only (termed “borate only”). For the Maine WAP program, cellulose insulation must be the “borate only” grade.

6100 Attic and Roof Insulation

6110 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.

6111 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 fixtures shall be blocked with rigid material to ensure a minimum insulation clearance of 3 inches and a maximum clearance of 6 inches.
 - a. Exceptions to this rule include Type IC (insulation contact) recessed lights and light/fan combinations, and closed junction boxes.
4. 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.
5. Knob-and-tube wiring:
 - a. If knob-and-tube wiring has been deactivated and the dwelling has been rewired with BX, Romex, or other approved electrical cable, the attic may be insulated over the inactive knob-and-tube.
 - b. Before insulation over live knob-and-tube wiring is approved, personnel authorizing work orders or contracts shall arrange for,

or conduct a thorough inspection of, the areas to be insulated and make sure that:

- i. All live wiring to be covered is examined and tested to ensure that the voltage drop in all subject knob-and-tube circuits is 10 percent or less.
 - ii. The electrical system has protective devices matched to the wire size that stop the flow of electrical current if the circuits are overloaded.
 1. Number 14 wire shall be fused with 15 amp fuses.
 2. Number 12 wire shall be fused with 20 amp fuses.
 - iii. "S" type fuses or breakers must be installed in the electrical panel serving any live knob-and-tube wiring.
 - iv. All of the above in "b" must be documented in the job file.
- c. If, for any reason, the items in "b" above cannot be completed, any insulation must be kept at least 3 inches from the live knob-and-tube wiring, unless the wiring has been approved or upgraded by a licensed electrician.
- i. Blown insulation must be appropriately dammed to keep the insulation 3 inches or more away from the knob-and-tube wiring.

6112 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.

6113 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 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.

6114 Attic Access

1. When it is necessary to install an interior attic access in the ceiling, it must be:
 - a. At least 4 square feet, and
 - b. At least 20 inches in width or length, and

- c. Shall be weatherstripped and insulated to the same level as the attic floor, or with at least 4 inches of extruded polystyrene (R-20).
2. In pre-1978 homes, installation of an attic access must be performed using lead-safe work practices, and all dust and debris caused by the installation shall be wet-cleaned.
3. 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. The use of fiberglass or other non-rigid material as a dam around the attic access is not allowed.
 - a. Examples of approved attic access insulation dam materials include:
 - i. Plywood of at least $\frac{3}{4}$ inch thickness.
 - ii. Wood board of at least $\frac{3}{4}$ inch thickness.
 - iii. Plywood of at least $\frac{1}{2}$ inch thickness with $\frac{3}{4}$ inch by 2- $\frac{1}{2}$ 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.
4. If there are no interior accesses, at least one exterior access to each attic space shall be left for inspection purposes. Before such access is sealed, the attic and/or knee wall area must be inspected by an appropriate agency or MSHA representative. This inspection must be adequately documented in the job file.
5. 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.

6115 Insulation Shielding and Blocking

1. All electrical fixtures shall be blocked with rigid material to ensure a minimum insulation clearance of 3 inches and a maximum clearance of 6 inches.
 - a. Exceptions to this rule include Type IC (insulation contact) recessed lights and light/fan combinations and closed junction boxes.
2. No insulation, including fire-rated insulation, shall be installed above recessed light fixtures so as to trap heat or prevent free air circulation. However, insulation may be installed over Type IC (insulation contact) light fixtures.

3. Blocking must be installed so that it is effective in shielding the heat source from the insulation, and no insulation shall be left within the blocked area.
4. Metal blocking must be notched so that it does not contact electrical wiring.
5. If insulation is added to the attic, rigid permanent blocking is required around the attic access openings if they open into a living area and adequate clearance exists.
6. Firestopping 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.”⁵ 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 of air around a chimney, a block must be installed to keep insulation 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 treated 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.
7. 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.

6120 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

⁵ NFPA 211 *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*, 2000 ed., 4-16.

stop air leakage. Seal knee wall floor cavities. Make sure bypasses are completely sealed before installing any insulation.

2. Attic insulation must completely cover heated areas 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 soffits vents or fill the eave/soffit area.
5. Insulation must be installed according to the manufacturer's specifications for coverage and R-value.
6. Attics should 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 should 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 12700 on page 120 for instructions.
7. If the installation of cellulose insulation on top of existing batt or blanket insulation is warranted, 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.

6121 Insulation Coverage and Density

1. Insulate uninsulated open-joint attics to at least R-38 in all dwellings that are heated and lived in year-round.
2. For attics with existing insulation, measure the density of the insulation in a selected test area before beginning the major installation. Blown insulation should be installed using any nozzle type or tubing method. The density of blown insulation 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/ft³.
 - b. Blown fiberglass at a density of 1.6 lb/ft³
4. Insulate knee wall cavities as follows:
 - a. Blown cellulose at a density of 3.25 to 3.75 lb/ft³.
 - b. Blown fiberglass at a density of 1.6 lb/ft³.

- 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 for sealing air leaks and bypasses 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 $\frac{1}{3}$ of the R-value away from the warm-side surface.
9. Add insulation as necessary to eliminate voids and areas of incomplete coverage. Cut or pull back existing fiberglass batts 1 to 2 feet from the soffit and blow the perimeter.

6122 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 job 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 $\frac{1}{2}$ inch drywall mudded once, or $\frac{3}{4}$ inch of wood.
3. If cellulose insulation is used, the cellulose shall be dense-packed in the vaulted or sloped ceiling/roof cavities.

6123 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.

6124 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).

6125 Attic Access Insulation

1. When it is necessary to install an interior access in the ceiling, it must be at least 4 square feet and at least 20 inches in width or length. It shall be weatherstripped and insulated with at least 4 inches of extruded polystyrene (R-20) that is properly secured to the exterior surface of the attic hatch.

6126 Ductwork Insulation

1. Ductwork must be sealed appropriately with the proper materials (duct mastic) before insulation is installed. Refer to Section 10120 on page 94 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.

6127 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.

6130 Attic Ventilation**6131 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. When roof vents are installed, they 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.

6132 High-Low Vents

1. Roof vents should be installed close to the peak.
2. Install high gable vents at least three feet above the soffit or a gable vent used for low venting.

6133 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.

6134 Knee Wall Ventilation

1. Knee walls or attic spaces that are sealed from other attic spaces may need to be ventilated as if they are separate attics.

6135 Attic Vent Area Guideline

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

6200 Sidewall Insulation

6210 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.

6211 Electrical Safeguards

- 1. Correct electrical problems such as unsafe wiring, open junction boxes that are accessible, or electrical code violations prior to performing any other work in the walls.
- 2. Knob-and-tube wiring:
 - a. If knob-and-tube wiring has been deactivated and the dwelling has been rewired with BX, Romex, or other approved electrical cable, the walls may be insulated around the inactive knob-and-tube.
 - b. Before approving insulation around live knob-and-tube wiring, personnel authorizing work orders or contracts shall arrange for or conduct a thorough inspection of the areas to be insulated to make sure that:
 - i. All live wiring that will be in contact with the installed insulation is examined and tested to ensure that the voltage drop in all knob-and-tube circuits is 10 percent or less.
 - ii. The electrical system has protective devices matched to the wire sizes that stop the flow of electrical current if the circuits are overloaded.
 - 1. Number 14 wire shall be fused with 15 amp fuses.
 - 2. Number 12 wire shall be fused with 20 amp fuses.
 - iii. "S" type fuses or breakers must be installed in the electrical panel serving any live knob-and-tube wiring.
 - iv. All of the above in "b" must be documented in the job file.

- c. If, for any reason, the items in “b” above cannot be completed, live knob-and-tube wiring must be approved or upgraded by a licensed electrician before insulation can be installed in any wall cavities.

6212 Moisture Inspection and Repair

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

6213 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. 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.

6214 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 a lot of lead paint dust and debris, so lead-safe work and clean-up practices must be employed. 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.

6215 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 as directed by the work order. Replace all missing 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.

6220 Installation Methods for Wall Insulation

1. Wall areas above windows and doors (except in mobile 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 if adding interior finish material and insulation is deemed cost-effective.
 - a. If faced fiberglass batt insulation is used, 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 in habitable areas.

- b. If wet-spray cellulose is used, a vapor barrier must be installed on the winter-warm side, 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. For all enclosed walls (where there is both exterior and interior surface finish materials), insulation must be installed using the tubing method rather than the nozzle method.
 - a. As an exception, a nozzle may be used in small cavities such as above windows and doors.
- 4. The tubing method may be used to install insulation in the sidewall by drilling one hole per story.
- 5. 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 3.2 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 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.

6221 Blocking

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

6222 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 using the bag or bladder method. This method is probably the most cost effective when considering time and materials.⁶
 - 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.
 - 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.

6223 Materials

1. *In site-built dwellings:*

⁶ 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.

- a. If possible, insulate all closed-cavity sidewalls to 3.25 - 3.75 lbs/ft³ with cellulose insulation. If it is not possible, document the reason in the job file.
 - b. Insulate open cavity walls with 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.
 - c. 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 once) or ¾ inch plywood.
2. For mobile home wall insulation materials, refer to Section 8800 on page 77.

6224 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/ft³ 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/ft³, documented reasons must be included in the job file.
3. When using blown fiberglass, install at a density of 1.6 lb/ft³.
4. Contractors must warranty wall insulation work for at least one year against voids of more than 5 percent.

6225 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.
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.

6226 Brick Siding

1. Interior drill and blow techniques are preferred for homes with brick veneer siding.

6227 Quality Control

1. A final inspection to assess quality and quantity of wall insulation must be performed. 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 possible, infrared scanning should 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 whenever the equipment is available and the use is practical.

6300 Foundation Insulation

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

6310 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.

6311 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 job file.
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. This barrier should overlap at least 6 inches at the joints, and extend 6 inches up the crawl space wall. 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 job file.
5. For basements with dirt floors, whenever feasible, install a non-skid moisture barrier on the floor. This barrier should overlap at least six inches at the joints, and extend six inches up the basement wall. Mobile home rubber roofing (EPDM) or rolled roofing qualifies as non-skid moisture barriers.

6312 Electrical Safeguards

1. Correct electrical problems such as unsafe wiring, uncovered junction boxes, or electrical hazards prior to performing any other work. If insulation exists, ensure that wiring is safe and meets applicable codes.
2. Knob-and-tube wiring:
 - a. If knob-and-tube wiring has been deactivated and the dwelling has been rewired with BX, Romex, or other approved electrical cable, the basement insulation may be in contact with the inactive knob-and-tube.

- b. Before personnel authorizing work orders or contracts approve the installation of insulation that will be in contact with live knob-and-tube wiring, they shall arrange for, or conduct a thorough inspection of, the areas to be insulated and make sure that:
 - i. All insulation to be in contact with live knob-and-tube wiring is examined and tested to ensure that the voltage drop in all subject knob-and-tube circuits is 10 percent or less.
 - ii. The electrical system has protective devices matched to the wire sizes that stop the flow of electrical current if the circuits are overloaded.
 - 1. Number 14 wire shall be fused with 15 amp fuses.
 - 2. Number 12 wire shall be fused with 20 amp fuses.
 - iii. “S” type fuses or breakers must be installed in the electrical panel serving any live knob-and-tube wiring.
 - iv. All of the above in “b” must be documented in the job file.

If, for any reason, the items in “b” above cannot be completed, any insulation must be kept at least 3 inches from the live knob-and-tube wiring, unless the wiring has been approved or upgraded by a licensed electrician.

6313 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 attached 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.

6314 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 3320 on page 18.
- 2. Repair any rotted, broken, or damaged structural components.

6315 Defining the Thermal Boundary

- 1. If the basement or crawl space houses a heating system or other appliance, it should be treated as a conditioned area. In this case – the most common – the basement or crawl space walls are part of the boundary of the conditioned 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.

2. 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 12700 on page 120 for instructions.
3. If the appropriate thermal boundary is determined to be the basement or crawl space wall (rather than the floor above the basement or crawl space), then the crawl space wall should be sealed, as necessary, before any insulation is installed on these surfaces.

6320 Installation Methods

6321 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 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).

6322 Materials

1. Interior basement wall insulation:
 - a. If the wall is studded out on the interior, it may be filled with unfaced fiberglass batt of an appropriate thickness, or with vinyl-faced fiberglass (metal building insulation). A polyethylene vapor barrier should be installed if the fiberglass does not have one.
 - b. Vinyl-faced fiberglass (metal building insulation) may be fastened at the band joist area and hung down 4 feet.
 - c. Interior rigid insulation may be glued and fastened to the basement wall.
 - d. Wet-spray cellulose insulation may not be used on basement or crawl space walls.
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 the finished 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. The exterior surface of these panels must be covered with a material that will protect it from ultraviolet light and physical damage.

6323 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.

6324 Rim or Band Joist Insulation

1. Insulation must be a minimum of R-10. MSHA recommends an R-19.
2. Fiberglass, rigid, or foam insulation may be used for this application. Whichever type is used, the installation must result in a savings-to-investment ratio of at least 1.00.
3. If there is significant air leakage, the band or rim joist area must be properly sealed before the insulation is installed.
4. The insulation must be secured in a permanent manner.

6325 Foundation Insulation

1. Route any exhaust fans to the outside using dampered vents, smoothbore rigid pipe, and an appropriate termination fixture.
2. If necessary, repair or replace exterior doors or door components to reduce air leakage. If necessary, replace all missing glass and repair or replace window components to reduce air leakage.
3. When foundation walls are insulated, no section above grade should be left uninsulated.
4. Fiberglass insulation must not be left exposed in habitable areas.
5. Mechanical fasteners must be used to secure perimeter insulation in a permanent manner.
6. 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 inside.
7. Interior wall installation:
 - a. Stud out the walls and insulate with fiberglass, or glue and fasten rigid insulation.
 - b. An alternative method for installing perimeter insulation is to attach metal-building insulation at the floor above the rim or band

joist, so that the blanket extends from the floor above to 4 feet down the foundation wall. It should be run horizontally in a continuous manner to eliminate as many seams as possible. The blanket may be slit at each floor joist to allow installation in a manner that minimizes gaps around the joist. The bottom of this fiberglass batt insulation should be air sealed to the wall with a strip of wood nailed to the foundation, or by sealing the vinyl facing to the wall with adhesive caulk.

- c. Other insulation types and methods may be used with the approval of the EHS or MSHA.
8. Exterior-wall installation:
- a. 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.

6326 Crawl space Insulation

- 1. Separate an unconditioned crawl space 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 and seal all joints with tape.
- 6. An alternative method for installing interior perimeter insulation is to attach 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. The blanket may be slit at each floor joist to allow installation in a manner that minimizes gaps around the joist. 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, which ever is appropriate.

- c. Mechanically fasten the insulation and seal all joints with tape.

6400 Floor Insulation

6410 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.

6411 Electrical Safeguards

1. Correct electrical problems such as unsafe wiring, open junction boxes, or other electrical hazards prior to performing any other work in the floor.
2. Do not use any metal mesh material, such as chicken wire, to support floor insulation. This can cause an electrical hazard to the installers.
3. Knob-and-tube wiring:
 - a. If knob-and-tube wiring has been deactivated and the dwelling has been rewired with BX, Romex, or other approved electrical cable, a floor may be insulated around and in contact with the inactive knob-and-tube.
 - b. Personnel authorizing work orders or contracts shall arrange for, or conduct a thorough inspection of, the areas to be insulated before approving insulation around live knob-and-tube wiring, and make sure that:
 - i. All live wiring to be covered is examined and tested to ensure that the voltage drop in all live knob-and-tube circuits is 10 percent or less.
 - ii. The electrical system has protective devices matched to the wire sizes and which stop the flow of electrical current if the circuits are overloaded.
 1. Number 14 wire shall be fused with 15 amp fuses.
 2. Number 12 wire shall be fused with 20 amp fuses.
 - iii. "S" type fuses or breakers must be installed in the electrical panel serving any knob-and-tube wiring.
 - iv. All of the above in "b" must be documented in the job file.

If, for any reason, the items in "b" above cannot be completed, any insulation must be kept at least 3 inches from the live knob-and-tube wiring unless the wiring has been approved or upgraded by a licensed electrician.

6412 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 area, the crawl space floor shall be covered with a moisture barrier when conditions warrant. This polyethylene must be lapped at least 6 inches at the joints and extended up the crawl space wall 6 inches.
3. Identification of potential moisture problems shall be documented in the job file.
4. Repair any moisture problems that will degrade or diminish the effectiveness of weatherization measures.

6413 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.

6420 Defining the Thermal Boundary

1. If the basement or crawl space houses a heating system and/or other appliances, it should be treated as a conditioned area. In this case – the most common – the basement or crawl space walls are part of the boundary of the conditioned 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.
2. 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 used to determine quality and completeness of air leakage and bypass sealing prior to, and then after, installing insulation. In addition, this test can help determine the appropriate location of the pressure and thermal boundaries. Please refer to Section 12700 on page 120 for instructions.
3. If the appropriate thermal 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.

6430 Installation Methods for Floor Insulation

1. Install a minimum of R-19 insulation between the floor joists.
2. The insulation should be installed without voids or gaps. Fit insulation tightly around cross bracing and any obstructions.
3. Floor insulation 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.
4. Whenever possible, install insulation so that it is in contact with the underside of the subfloor above.
5. Faced fiberglass insulation must have the facing upward toward the heated area.
6. Ensure that floor insulation is in direct contact with the rim or band joints. If the dwelling is balloon framed, airseal the bottom of the stud cavities prior to installing the insulation.
7. Fiberglass insulation must not be left exposed in habitable spaces.

6431 Materials

1. Fiberglass insulation, faced or unfaced, is the preferred insulation material for perimeter and floor.
2. It is preferred that vinyl faced insulation not be used for floor insulation.

6432 Insulation Coverage

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

6433 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 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).

6434 Ducts and Pipes

1. When floor insulation is installed, ductwork below the floor insulation must be appropriately sealed and insulated. Please refer to Section 10130 on page 95 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 10210 and 10220, starting on page 96.
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.

6440 Crawl space Ventilation

1. If the crawl space walls or ceiling are insulated and a moisture barrier covers the crawl space floor, the crawl space shall not be vented to the outdoors. If a moisture barrier cannot be installed, the crawl space must be vented. If a ground cover cannot be installed, the reason shall be documented in the job file.
 - a. If crawl space vents are provided, they must provide 1 square foot of free vent area for every 1,500 square feet of crawl space ground area if there is a polyethylene ground cover, or 1 square foot of 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.
2. If there are more vents than are 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. Do not close off or restrict combustion air vents.

7000 Window and Door Replacements

7100 Primary Windows

7110 Window Assessment

1. All existing egress windows must remain operable.
2. Non-operable windows may be permanently sealed against air leakage.

7120 Window Replacements

1. Window replacements must be based primarily on an energy-conservation decision process rather than on client requests or aesthetics.
2. Replacement of windows must be justified by the MEADOW audit.
3. The installation of replacement windows must meet applicable building codes.

7130 Window Air Leakage

1. Window tightening measures such as caulking and weather-stripping must be presumed to be cost-effective based on the MEADOW audit.

7140 Window Repairs

1. When feasible, windows must be repaired, rather than replaced.
2. Replace missing, broken and 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.

7200 Storm Windows and Insulation Systems

7210 Interior Storm Windows

1. Interior storm windows shall be installed in mobile homes whenever feasible and cost effective (as determined by the MEADOW 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. Storm windows may be installed as a replacement for non-repairable existing storm windows when this measure is determined to be cost-effective by the approved Maine energy audit program.
7. Metal storm windows should not come in contact with frames or fasteners constructed of dissimilar metals.
8. 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.
9. Operable storm windows shall move freely.

7220 Movable Window Insulation Systems

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

7230 Non-Allowable Window Materials

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

7300 Doors

7310 Door Assessment

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

7320 Door Replacements

1. Individual replacement doors may only be installed if the cost of the repair is justified by the MEADOW audit.
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
 - b. The installation of a door that is not pre-hung.
 - c. 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.

7330 Air Leaks in Doors

1. With the exception of isolated installations to address client comfort, air leak mitigation measures for doors such as jamb-up kits, sweeps, and thresholds must be determined to be cost-effective based on the MEADOW audit.

7340 Door Repairs

1. When feasible, a door must be repaired rather than replaced.
2. Stuck doors do not have to be made operable.

8000 Mobile Home Requirements

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

8100 Inspections, Preparation, and Repairs

1. The structure shall be properly supported, leveled, and restrained (if required) 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 repairs must be repaired if insulation will be installed, or if significant air leakage is occurring.

8110 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 job file.

8120 Electrical Inspections

1. Before insulating units, assess the electrical wiring and the circuit breaker/fuse box as follows:
 - a. #12 aluminum or #14 copper wiring must be protected with 15 amp fuses or breakers; and
 - b. The client should be asked about any known existing electrical problems.
2. If there is reason to believe, before or after installing wall insulation, that a mobile home has aluminum wiring, it is recommended that an

electrical inspection be performed by a licensed electrician following the completion of the insulation work.

3. Care must be taken to ensure that electrical wiring was not damaged during insulation work. This can be done by testing electrical outlets and switches after completing the work.

8200 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 building tightness limit procedure and calculation in Section 12200 on page 109 of these standards.
3. Only the following air leakage reduction measures may be installed when the existing CFM₅₀ measurement is below the calculated building tightness limit:
 - 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. Air leak mitigation measures that enhance client comfort (for example, installing a storm window near a reading chair, installing a jamb weatherstrip kit on a door near a reading chair, etc.) must be documented with a brief explanation in the client file.
5. Snap fasteners and/or weatherstripping shall be used whenever possible to reduce air and/or water leaks around primary windows.
6. Major air leaks around single-pane windows that cannot be eliminated with sidewall insulation or snap fasteners shall have an interior storm window installed or the window replaced, whichever is most cost-effective.
7. Caulking is recommended around all interior casing when there is an interior storm window.
8. When accessible, the joint between the two sections of a double-wide must be filled and sealed from underneath the structure.
9. Large holes in water heater closets with an exterior wall must be sealed, with care taken not to seal off combustion air from the outside.

8300 General Insulation

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

8400 Ceiling Insulation

1. Recessed lighting fixtures and fan/light combinations that are Type IC rated by UL may be covered with insulation.
2. Ventilation fans may be covered with insulation if all holes and penetrations are sealed with a nonflammable sealant.
3. Thermal insulation shall not be installed within 3 inches of fan/light fixtures or recessed light fixtures are not Type IC.
4. All combustible insulation materials shall be kept at least 2 inches from metal flues and chimneys.
5. The ceiling and roof condition must be inspected and assessed before installing insulation.
6. If it is cost effective, ceilings that appear weak shall be repaired or reinforced – especially in heavy snow load areas – before installing insulation.
7. 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.
8. Ceiling insulation must be installed in a manner that ensures complete coverage over heated areas, except those areas requiring and receiving a technical waiver.
9. Average insulation densities for loose fill insulation installed in mobile home ceiling cavities shall be:
 - a. Fiberglass – 1.25 to 1.75 lbs/ft³.
10. Mobile home ceilings shall not be dense-packed with cellulose or over-filled so as to create structural problems in the ceiling.
11. If an interior drill-and-blow method is used for installing insulation, holes must be plugged and sealed properly. In addition, the hole pattern must be adequate to ensure complete coverage.
12. If an exterior or side-opening 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.
13. Fiberglass is the preferred insulation material for mobile home ceilings.

14. Avoid cutting large holes and using screws on top of metal roofs, especially in heavy snow load areas.
15. 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, clients should be advised to refrain from shoveling snow off the roof. Instead, they should use a push broom, and only if absolutely necessary.

8500 Ductwork

8510 General

1. Fiberglass (with the exception of duct board) shall not be left exposed on the inside of ductwork.
2. Any portion of the ductwork that extends beyond the last register or grille may be sealed.
3. 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.

8520 Belly Return Conversions

1. Mobile home belly return air systems must be permanently sealed from the occupiable space. A living space return air system must be created by:
 - a. Either removing the furnace closet door, or installing an adequately sized return air grille(s) in the furnace closet door;
 - b. Sealing the return grilles in the floors of bedrooms, bathroom, kitchen, living area, etc.;
 - c. Sealing the return air grille in the furnace closet floor; and
 - d. Allowing for return airflow under closed bedroom and bathroom doors in a manner that reduces the room-to-room pressure difference – with the door closed and the air handler operating – to 3 Pascals or less.
 - e. *Note:* Please refer to Section 8700 on page 75 for more details about this duct distribution conversion.
2. For a discussion of duct leakage measurements and standards, follow the instructions in Section 5600 on page 38.

3. For ductwork sealing and insulation, follow the instructions in Section 10100 on page 93.

8530 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.
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 may be replaced with new flexible 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.

8600 Floor (Belly) Insulation**8610 Floor Insulation Requirements**

1. Belly rodent barriers must be inspected for general condition, structural strength, and major air leaks prior to installing insulation.
2. 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.
3. 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.
4. 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 rodent barrier, then the following measure must be attempted, if it is cost effective and feasible:

- 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. *Note:* If none of these measures can be taken, then the belly shall be insulated using the perimeter method.
5. Belly insulation shall be installed only after all repairs have been made, major holes in the rodent barrier and floor have been sealed, and all ductwork has been sealed according to Section 5600 on page 38.
 6. Belly insulation must be installed in a manner that ensures complete coverage of all heated areas except those requiring and receiving a technical waiver.
 7. Holes that have been made in belly rodent barriers for the installation of insulation must be patched and sealed.
 8. Rim joists may not be drilled if they are determined to be a structural component of the foundation support system.
 9. Average insulation densities for loose fill insulation installed in mobile home bellies shall be:
 - a. Fiberglass – 1.25 to 1.75 lbs./ft³
 10. Bellies shall not be dense-packed with cellulose or over-filled so as to create undue stress on the belly rodent barrier.

8620 Floor Insulation Methods

1. Fiberglass is the preferred insulation material for mobile home bellies.
2. Bellies that hang up to 8 inches 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, but only after attempts have been made to bring the rodent barrier closer to the floor above. This must be done with care to avoid damaging the duct trunk line or water lines in the belly.
4. Access through the rim joist and the use of a metal fill tube are the preferred methods for installing mobile home belly insulation.
5. If bellies cannot be insulated through the rim joist and must be insulated from underneath, the use of the insulation hose or a large diameter fill tube is preferred; a 90° nozzle may not be used.
6. When insulation has to be installed from underneath the belly, it is preferred that the first person to go underneath install a 6 mil vapor

barrier on the ground in order to reduce health risks to the installers from animal feces.

7. Make belly patches lasting and secure by using adhesives, clinch staples, screws, and lath strips whenever possible.
8. Insulated sheathing board, fiberboard, and nylon-reinforced belly bottom material specifically manufactured for mobile homes are the preferred patching materials for large holes in belly rodent barriers.
9. Ductwork shall be inspected for insulation that might have accidentally gotten inside the ductwork during insulation work.
10. The furnace shall be cycled to ensure proper operation.
11. Upon completing insulation work, 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.
12. Installing mobile home skirting requires prior MSHA approval.
13. Minor repairs to existing skirting are allowed. Contact MSHA for clarification.

8700 Mobile Home Belly Return Conversion

8710 Introduction

Belly return systems in mobile homes are notoriously leaky. These leaky return systems can significantly increase the space heating costs and lead to thermal discomfort and indoor air quality problems.

All belly return systems shall be converted to a living space return system. Follow the procedures below.

8720 Conversion Process

When converting a belly return system in a mobile 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 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° and 80° F.

- a. Inspect and, if necessary, repair the plenum/furnace joint before measuring the temperature rise.
 - b. Make sure all interior doors are open, except the furnace closet door.
 - c. Close the furnace closet door completely.
 - d. Turn on the furnace and allow the temperature of the supply air to stabilize. Measure the temperature at the register closest to the furnace, 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.
 - e. Subtract the house air temperature – the return air – from the supply air temperature. The difference is the temperature rise.
 - f. If the temperature rise is greater than the recommended range, the airflow is probably being restricted by:
 - i. An undersized opening in the furnace closet door, or
 - ii. Another restriction in the ductwork.
 - g. If the temperature rise is less than the recommended range, there might be:
 - i. Significant leakage at the furnace/plenum joint, or
 - ii. Significant leakage in the duct between the furnace and the location of your supply air temperature measurement.
 - h. If the temperature rise is out of range, repair the cause of the problem by removing any restriction to airflow or repairing leaks. Check the temperature rise again. Once the temperature rise is within the recommended range, move on to the next step.
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.

8800 Sidewall Insulation

8810 Sidewall Insulation Requirements

1. Mobile home sidewalls shall be insulated when the MEADOW audit shows it is cost-effective.
2. The exterior siding and the interior wall materials must be inspected prior to the installation of insulation.
3. Weak or damaged wall materials must be repaired or reinforced prior to installing insulation.
4. Electrical precautions:
 - a. If there is reason to believe, before or after installing wall insulation, that a mobile home has aluminum wiring, it is recommended that an electrical inspection be performed by a licensed electrician following completion of the insulation work.
 - b. Electrical wiring and the electrical circuit breaker/fuse box must be assessed for adequacy (please refer to Section 8120 on page 69). The client should be asked about any existing electrical problems, especially in the wall outlets or switches.
 - c. If aluminum wiring is present, extra care must be taken to ensure the electrical system is not damaged during insulation work. The following steps must be taken:
 - i. Each cavity that contains an outlet, switch, or light fixture should be clearly identified and marked on the outside siding prior to the installation of the insulation, and these cavities should be carefully tubed rather than stuffed with a batt. If the wires will be moved too much, regardless of how carefully the cavity is tubed, then the cavity should not be insulated.
 - ii. Each outlet, switch, or light fixture must be checked for proper operation with a receptacle tester immediately following the completion of the insulation work.
 - d. If any one of the above two steps cannot be completed, the sidewalls shall not be insulated, and documentation stating the reason for omission must be placed in the client file.
5. Installing insulation above windows and doors is usually not feasible or cost-effective and is not required in mobile homes.
6. Mobile home sidewalls shall not be dense-packed or over-filled so as to create siding or interior wall structural problems.

8820 Sidewall Insulation Methods

1. Vinyl faced fiberglass batt insulation and loose fill fiberglass are the preferred insulation materials for mobile home sidewalls.
2. The batt-stuffing method with vinyl-faced fiberglass is the favored technique for insulating wall cavities.
3. For cavities that cannot or should not be insulated with the batt-stuffing technique, the fill-tube method with loose fill fiberglass is recommended.

8900 *Insulation of Water Supply Systems*

1. Water pipes that have not been covered by under-floor insulation should be insulated to a minimum of R-3 by the owner.
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 be either 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.
5. To prevent freezing, box the individual water supply system pressure tank with 2 inches of extruded polystyrene insulation. Make sure the outer surface of this insulation is protected from direct sunlight.

81000 *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 possible. 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 closet door and adjacent wall area:
 - i. The tank should be wrapped with an insulation blanket. Please refer to Section 10300 on page 97 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.

81100 Combustion Systems

- 1. If interior combustion air is used for the furnace, replacement with a sealed combustion (direct-vent) furnace is mandatory.

9000 Combustion Appliances

9100 Combustion Appliance Requirements

The efficient operation of heating systems is a critical aspect of efficient energy use.

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.

9110 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 9120 on page 81) and components (see Section 9130 on page 82).
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 Sections 2000 and 9100.

9120 Combustion Efficiency and Analysis

Acceptable combustion analysis values are found in Table 9-1.

1. The steady-state efficiency of a central heating system should be checked to determine:
 - a. If it needs cleaning and tuning.
 - b. If it functions as efficiently as it was designed to.
 - i. (Refer to Section 9135 on page 88 for steady-state efficiency testing instructions.)
2. Replace the heating system if the MEADOW audit determines that it is cost-effective to do so.

Table 9-1

Acceptable Combustion Test Analysis Values				
Heating Unit Type	Oxygen (O₂)	Carbon Dioxide (CO₂)	Net Stack Temp.	Smoke Test
Gas				
Atmospheric	4 - 9%	Natural 9.6 - 6.8% LPG 11.2 - 7.8%	300-600° F	NA
Fan-assisted	4 - 9%	Natural 9.6 - 6.8% LPG 11.2 - 7.8%	300-480° 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%	300-650° F	NA
Oil (No. 1 & 2)				
Oil gun burner	4 - 9%	12.5 - 8.8%	325-600° F	1 or less
Flame Retention burner	4 - 7%	12.5 - 10.3%	325-600° F	1 or less

9130 Space Heating System Requirements

1. Health and safety requirements for space heating systems are required. Please refer to Section 3400 on page 27 for details.

9131 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. 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:* All identified gas leaks should be referred to appropriate persons for repair or replacement. Hold the leak detector probe just below a propane gas line and just above a natural gas line.
 - 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 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 have 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/gas valve*: The heating system must have a thermostat in working condition that is compatible with the control circuit type (24 volt vs. millivolt). 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.
4. *Fan on/fan off*: Ideally, the fan-off temperature is between 95° and 100°F, but never below 80°F. The fan-on target range is between the fan-off temperature and 130°F, but never to exceed 140°F.
5. *Limit switch*: This switch should shut the burner off at approximately 200°F, where appropriate.
6. *Heat rise*: Furnace heat rise should fall within the manufacturer's recommended temperature range. If this information is not available, the heat rise should fall within a 40° to 80°F range. The furnace must not cycle on the high-limit switch.
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.
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 draft test procedures (see Section 12500 on page 114).

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 draft testing procedures in Section 12500 on page 114. Please refer to Section 5621 on page 38 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.

9132 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*: All identified gas leaks should be referred to appropriate persons for repair or replacement. Hold the leak detector probe just below a propane gas line and just above a natural gas line.
 - 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/gas valve*: The furnace must have a thermostat in working condition that is compatible with the control circuit type (24 volt vs. millivolt). 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°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 the exception of direct-vent units, must be tested with worst-case draft test procedures (see Section 12500 on page 114).
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% 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.

9133 Mobile Home Sealed Combustion Furnaces

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

1. *Gas-fired unit requirements*
 - a. *Gas Leaks*: All identified gas leaks should be referred to appropriate persons for repair or replacement. Hold the leak

detector probe just below a propane gas line or just above a natural gas line.

- 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/gas valve*: The furnace must have a thermostat in working condition that is compatible with the control circuit type (24 volt vs. millivolt). 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 mobile home thermostats be located on an interior wall.
5. *Fan-on/fan-off*: Ideally, the fan-off temperature is between 95° and 100°F, but never below 80°F. The fan-on target range is between the fan-off setting and 130°F, but must never exceed 140°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°F, where appropriate.

7. *Heat Rise:* Heat rise should fall within the manufacturer's recommended temperature range. If this information is not available, the heat rise should fall within a 40° to 80°F range. The furnace must not cycle on the high-limit switch.
8. *Ductwork:* For a discussion of duct leakage measurements and standards, follow the instructions in Section 5600 on page 38. For ductwork sealing and insulation, follow the instructions in Section 10100 on page 93.
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.

9134 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:* All identified gas leaks should be referred to appropriate persons for repair or replacement. Hold the leak detector probe just below a propane gas line or just above a natural gas line.
 - 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. *Constant temperature boilers* in single-family residences should be converted to cold-start type boilers whenever feasible.
- 4. *Thermostat/gas valve*: The boiler must have a thermostat in working condition that is compatible with the control circuit type (24 volt vs. millivolt). 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 valves*: 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.
- 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 test procedures (see Section 12500 on page 114).
- 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.

9135 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 and 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 (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.
- 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 9-2.

Table 9-2

Atmospheric Gas Appliances Only					
Acceptable Draft Test Readings for Various Outdoor					
Temperature Ranges					
°F	<20	21-40	41-60	61-80	>80
Pascals	-5	-4	-3	-2	-1
Water Column inches	-0.02	-0.016	-0.012	-0.008	-0.004

b. Oil systems

- 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 gauge (W.G.). 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 W.G.).
- iii. Acceptable draft values for oil-fired systems are listed in Table 9-3.

Table 9-3

Power Oil Burners	
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

3. Measurement of heat rise across heat exchanger

a. Up-flow furnaces

- i. *Supply side:* Drill a hole and insert the thermometer in the supply plenum as close as possible to the heat exchanger, but “out of sight” of the heat exchanger (this ensures that the reading will not be affected by radiant thermal energy from the heat exchanger). If the furnace plenum houses a central

- air conditioning coil, be very careful to avoid damaging this coil. Drill the hole beyond the cooling coil.
- ii. *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.
- b. *Horizontal-flow furnaces*
- i. 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).
 - ii. *Return side:* Drill a hole and insert the thermometer into the return plenum approximately 2 feet before the filter.
- c. *Down-flow furnaces (mobile home):* The furnace compartment door should be closed while taking the temperature readings.
- i. *Supply side:* Test the supply side air temperature at the supply register closest to the furnace. Insert the thermometer probe into the register for the most accurate reading.
 - ii. *Return side:* 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. *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.
- 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 (mobile home):* Place the thermometer through the slots in the top center of the blower compartment cover, with the cover in place.
5. *Heat exchanger integrity:*
- a. When performing a steady-state efficiency test on a furnace and the CO, CO₂, or O₂ values change when the furnace distribution blower fan starts, it might indicate a cracked or defective heat exchanger.

9136 Water Heater Inspection

All gas-fired water heaters must meet the following specifications:

1. All identified gas leaks should be referred to the appropriate person for repair. All gas leaks should be documented in the client file.
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 draft test procedures (see Section 12500 on page 114).
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 50 ppm, or 100 ppm air-free.
5. All water heaters must have a water temperature test. If the water temperature is above 120°F at a faucet near the water heater, the client should be informed about the advantages and disadvantages of lowering the water temperature. If the client agrees to an adjustment, lower the water temperature to 120°F. Mark the old setting on the control as a reference point.
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.

9137 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.

9138 All Other Heating Systems

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

9140 Central Air Conditioning in Manufactured Homes

1. In some cases, when mobile 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.

10000 Heating System Distribution and Domestic Water Heating

10100 Ducted Distribution Requirements

Ductwork treatment is dependent on a number of factors, including its location, accessibility, its impact on dwelling pressures, and its condition.

10110 Ductwork Inspection, Cleaning, and Sealing

1. Ductwork must be tested and sealed according to Section 5600 on page 38, Duct Leakage Testing.
2. Delivery and return ductwork must be cleaned as necessary to remove large objects and debris that may impede airflow through the heating system.
3. Uncover any blocked registers or grilles. Explain to the client the importance of maintaining the unrestricted airflow.
4. As necessary, delivery and return air grilles and registers must be removed and cleaned to remove excessive dirt and debris that may impede airflow.
5. When appropriate, remove and block off ducts, registers, and grilles located in unconditioned spaces.
6. Ductwork outside the thermal envelope of the dwelling must be sealed with mastic and insulated.
7. 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 12500 on page 114 for Worst-Case Draft Testing procedures.
8. Ducts and registers into non-living areas of the structure may be sealed off with the owner's permission.
9. Existing crawl space plenums should be abandoned and replaced with a sealed duct system.
10. Cloth duct tape shall never be used for duct sealing.
11. Ductwork sealing shall be done with mastic, mesh tape, sheet metal, or pressure sensitive metal tape.
 - a. Gaps of 1/8 inch or less may be sealed with:
 - i. Duct mastic.
 - ii. Pressure sensitive metal tape
 - b. Gaps between 1/8 inch and 1 inch shall be sealed with:
 - i. Duct mastic embedded with fiberglass mesh.
 - c. Gaps larger than 1 inch shall be covered with sheet metal or valley flashing, fastened with screws, and sealed with mastic.

12. New ductwork installations may not include panned joists or stud cavities for ducts. All passageways for distribution air must be hard ducted.
13. 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 mastic or other appropriate materials.

10120 Ductwork Sealing Materials

1. *Cloth duct tape shall never be used for duct sealing.*
2. Existing duct tape must be removed before installing duct mastic or other approved sealing materials
3. Mastic shall meet the following requirements:
 - a. Non-toxic and water-resistant.
 - b. UL listed and labeled per UL 181A or 181B standards.
 - c. Shall be compatible with the duct material to which it is applied.
4. Mesh fabric used to reinforce duct mastic shall meet the following requirements:
 - a. Comply with the mastic manufacturer's specifications.
 - b. Made of fiberglass.
 - c. Have at least a 9 x 9 weave per inch.
 - d. Be at least 0.006 inches in thickness.
5. Pressure sensitive metal tape shall meet the following requirements:
 - a. UL listed and labeled per UL 181A or 181B standards.
 - b. Tape width must be at least 2 inches.
 - c. Butyl adhesive must be at least 15 mils thick.
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°F.
7. Duct supports shall conform to the duct manufacturer's installation instructions and must be corrosion resistant.

10130 Ductwork Insulation

1. Active ductwork outside the thermal envelope must be repaired if damaged, sealed, and insulated.
 - a. Prior to installing insulation, ductwork must be sealed according to these standards.
 - 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.

10140 New Ductwork Installations

1. Ducts, supply registers, and return grilles should 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.

10200 Piped Distribution Requirements

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

10210 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 living habitable 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.

10220 Domestic Hot Water Pipes

1. Make certain there are no leaks in domestic hot water pipes.
2. Insulate the first 9 feet of hot water pipe and the first 3 feet of cold water pipe with $\frac{3}{4}$ 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.

10300 Water Heater Blankets

The installation of water heater blankets on electric water heaters in conditioned spaces is recommended unless this will void the 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.

10310 Water Heater Blanket Materials

1. The water heater blanket must be fiberglass batt insulation with a protective covering.
2. An R-11 water heater blanket is preferred on all tanks not labeled with a prohibition to installing additional insulation to that already installed 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.

10320 Installation

1. The water heater tank must be inspected to determine the type of water heater (gas, electric, other), and whenever possible, the amount of existing insulation.
2. If there are signs that the water heater is leaking, this problem must be solved before insulation is added.
3. Electric water heaters outside the occupiable space, including mobile home water heaters in exterior closets, must be insulated if the total existing tank insulation is less than R-11.

4. A water heater blanket must not be installed when a temperature and pressure relief valve does not exist or when the existing temperature and pressure relief does not operate properly.
5. A water heater blanket must not cover the following:
 - a. The temperature and pressure relief valve on an electric unit.
 - b. The drain valve on an electric unit.
 - c. Where the electrical line attaches to an electric unit. Insulation must be kept at least two inches away from where this electrical line attaches to the water heater.

10400 Domestic Hot Water Temperature

1. Whenever feasible, the domestic hot water temperature must be measured and reduced to 120°F or less with the approval of the client/owner.
2. The client/owner must be informed that lowering the temperature of the water will result in less thermal energy stored in the hot water; therefore, they may run out of hot water sooner.
3. The original water temperature setting must be marked on the thermostatic control.

10500 Energy-Saving Showerheads

1. An energy-saving (low-flow) showerhead may be installed with client permission, if the existing showerhead flow is measured at greater than 3 gallons per minute (gpm) and the installation does not require the use of a plumber.
2. The energy-saving showerhead must have a flow rating of 2.5 gpm or less.
3. If an energy-saving showerhead is installed in conjunction with lowering the domestic hot water temperature, the chances are high that the client will not notice less hot water for showering, as they might if the temperature is reduced without installing the new showerhead.

11000 Final Inspection Procedures

The Department of Energy and MSHA 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 MSHA) as completed until all weatherization materials have been installed and the subgrantee (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.”⁷

The final inspection must be performed by a Senior Energy Auditor. Energy auditors who have not achieved Senior Energy Auditor status cannot perform a final inspection without the accompaniment of a Senior Energy Auditor.

11100 General Requirements – 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. Any exterior wood trim installed on the home shall have all four sides primed to match the existing finish on the home. 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 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 pine trim installed shall be free of loose knots and all sides should be finished.
4. MSHA 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. If any new trim is required to match the existing finish, the color or pattern shall be selected by the owner.

⁷ 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).

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. All repair work shall conform to the local building codes when applicable. Where applicable, repair work completed shall also conform to the following standards: the *BOCA National Plumbing Code*; the *NFPA 70 National Electric Code*; *NFPA 101 Life Safety Code*; American Society for Testing Materials (ASTM) Standards; and the International Code Council (ICC/ANSI A117.1-98) *Standards for Accessible and Usable Buildings and Facilities*. The above-mentioned standards when applicable will be noted by the energy auditor.

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

11200 General Final Inspection Items

1. The Senior Auditor is responsible for ensuring all items specified in the work order have been completed in a professional and workmanlike manner.
2. The Senior Auditor shall assess the job to ensure that the contractor has not damaged any existing finishes and items in the home.
3. The Senior Auditor shall also ensure that the contractor or crew have left the dwelling in a clean and orderly manner.
4. The work order shall be followed at all times during the final inspection and any items that have not been completed to the satisfaction of the Senior Auditor must be noted on an agency rework form. This form is generated by the Senior Auditors agency and shall not be confused with the MSHA rework form generated during annual monitoring visits.
5. The Senior Auditor is responsible for obtaining all the proper homeowner signatures on the final sign-off for the project.
6. All paperwork is required to be placed in the job file.

11300 Inspection of Wall Insulation

1. Verify that the sidewall insulation has been installed in all required wall cavities. Use infrared scanning for this inspection whenever possible.
2. All structural damage on the work order should have been repaired 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.
3. Any replaced wood siding or trim must match the existing grade and be primed with an appropriate paint or stain.
4. Verify that blown insulation has not deformed or damaged the interior wall surfaces.
5. If the insulation was blown into the wall cavities from the inside, make sure that:
 - a. The interior fill holes have been filled properly and patched and that the final finish is as close to the original as possible.
 - b. Verify that no insulation or debris is left in the house.
6. Verify that insulation has not escaped into wall heaters, vent fans, ducts, or other mechanical penetrations.
7. Make sure that structural details such as interior soffits, pocket doors, and other bypasses have been properly addressed during the insulation installation.
8. Make sure the siding has been reinstalled properly and that the siding removal and replacement of siding has not unnecessarily damaged the siding or trim.
9. If the finished siding has been face-drilled and plugged, make sure that the reasons for doing so are included in the client file along with a permission form signed by the client.
10. Verify that cellulose insulation has been installed at the proper density.
 - a. Cellulose should be installed at a high density in walls whenever conditions permit. High density is at least 3.25 pounds per cubic foot.
 - b. The density may be determined by
 - i. Core sampling after the insulation is installed.
 - 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.

- iii. Other methods approved by MSHA.

11400 Inspection of Attic Insulation

1. Verify that damaged or rotted 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 repaired.
3. All appropriate attic bypass and safety items must have been completed properly, including:
 - a. Chimney bypasses.
 - b. Plumbing stack bypasses.
 - c. Attic hatch or pull-down stair sealing and insulating.
 - d. Recessed light damming.
 - e. Junction boxes.
 - f. Bathroom and kitchen exhaust fan venting.
 - g. Knob-and-tube wiring.
4. Verify that the proper type and amount of attic insulation has been installed. Uninsulated attics must be insulated to at least R-38.
 - a. Cellulose insulation must be installed to allow for 10 percent settling. For example, if 12 inches of cellulose are called for on the work order, 14 inches must be installed so that the *settled thickness* is 12 inches.
 - b. The thickness of blown 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. Attic ventilation shall not be blocked with installed insulation.

11500 Inspection of Attic Access and Knee Wall Doors

1. Make sure the attic hatch is at least 4 square feet and at least 20 inches in width or length, weatherstripped. 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 pull-down stairs are properly insulated and weatherstripped.
3. Make sure knee wall access doors are properly insulated, weatherstripped, and latched.

11600 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.
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.
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 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 according to the work order.

11700 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.
2. Verify that dryer vents are extended to the outdoors.
3. Verify that the dryer vent is installed according to Section 3364 on page 24.

11800 Inspection of Kitchen and Bathroom 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 rigid or flexible metal (no vinyl) duct.
2. Verify that all exhaust fans comply with Section 3380 on page 25.
3. Make sure the client knows how to properly use all newly installed exhaust fans.
4. If ASHRAE Standard 62.2-2004 is being used to size ventilation fans, verify that the exhaust fans are working properly and are exhausting at the required CFM rate.
 - a. Measure the actual exhaust fan CFM rate with the Exhaust Fan Flow Meter from The Energy Conservatory or with a similar device.

12000 Diagnostic Testing Procedures

12100 Blower Door Testing

12110 Introduction

The use of a blower door as a weatherization tool is very important. It can be 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 (TEC) Minneapolis Blower Door, Model 3, with the companion TEC analog magnehelic gauges or the TEC digital manometers, Model DG-3 or DG-700.

12120 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 on the Minneapolis Blower Door, Model 3, is the white ring that is permanently attached to the end of the motor opposite the fan blade. It is one of the most critical parts of the blower door fan. Make sure the sensor is in its proper position, not damaged, that the connected hose is in good condition, and that the 4 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. Magnehelic gauges (round with needle indicators) should be calibrated once every 5 years by the manufacturer.
 - d. Digital pressure gauges should be calibrated annually by the manufacturer.

- e. For detailed maintenance recommendations for equipment manufactured by The Energy Conservatory, go to <http://www.energyconservatory.com/manuals.html> and download the Maintenance Tips.
2. Deactivate all vented combustion appliances before depressurizing the structure by turning the thermostat down, or by shutting the appliance off.
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 prime 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 conditioned area, determine the CFM₅₀ value with the blower door with the basement door closed and with the basement door opened.
8. Set up the blower door unit in an exterior door opening in an area free from obstructions and wind interference.

12130 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 (or low flow plate) is facing toward the inside of the house. Set up the fan in a level, or nearly level, position.
4. Set up the magnehelic or digital gauges in a vertical position.
5. 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.

6. Insert the hose from the house pressure gauge into the hole in the door panel. As an alternative, you may route the house pressure hose between the fan housing and the nylon fabric. Make sure that the end of the hose is not in front of the fan outlet or positioned so that it is exposed to windy conditions. Leave the fan pressure gauge tube end inside the house (not connected to the fan). Ensure that the fabric cover or all the rings and the center plug are on the fan.
 - a. If you are using the magnehelic gauges, zero all three of them.
 - b. If you are using the DG-3 digital manometer, record the baseline pressure reading. This reading is usually a result of stack pressure. When you depressurize the house with the blower door, make sure to bring the house to a pressure that is 50 Pascals less than this baseline pressure. For example, if the baseline pressure is -3 Pascals, depressurize the house to -53 Pascals. If the baseline pressure is -5 Pascals, depressurize the house to -55 Pascals. Install the open end of the fan pressure gauge tube onto the blower door fan pressure tap.
 - i. If you change blower rings while performing a blower door test, make sure to change the "CONFIG" setting on the DG-3 to correspond.
 - c. If you are using the DG-700 digital manometer, record the baseline pressure reading according to the manometer instruction. This reading is usually a result of stack pressure. Once you enter the baseline value into the DG-700, you can proceed with the blower door test without being concerned with the baseline value, except as noted below.
 - i. If you turn the DG-700 off and on again or press the "MODE" or "CLEAR" button, you must re-enter the baseline again for a valid blower door test.
 - ii. If you change blower rings while performing a blower door test, make sure to change the "CONFIG" setting on the DG-700 to correspond. If you do this, there is no reason to enter the baseline again.
7. Perform a one-point test by depressurizing to -50 Pascals house pressure or, if unable to reach -50 Pascals, the highest possible house pressure possible. Use one of the flow rings if the fan pressure is less than 25 Pascals. If wind seems to be affecting the test results, take several one-point tests and average the results.
8. Calculate the CFM_{50} of the dwelling by using the markings on the magnehelic gauges, digital gauges, ZipTest Pro™ software in the TI-86 calculator, or the blower door tables.

12140 Blower Door Test, Pressurization

1. Use the pressurization blower door test only if a solid fuel heating unit or a drip-pot, oil-burning space heater is in operation, or for some other reason, it is approved by the Maine weatherization program.
2. Install the door panel as it is normally.
3. Attach a tube to the lower tap of the house pressure gauge and run the other end of the hose through the hole in the upper part of the door panel, making sure it is away from the fan outlet. See the digital manometer instructions for the proper hose connection for house pressurization.
4. Leave the fan pressure hose "Tee" attached to the gauges and fan, as it normally would be for a depressurization test.
5. Attach an extra "Tee" to the upper taps of the fan pressure gauge, and run the other end of the hose to the outdoors, away from any fan turbulence.
6. Install the fan with the flow rings/low-flow plate facing the outdoors. The fan hose and the extra hose will run outside between the fan housing and the elastic collar. The fan speed control must remain on the indoor side.
7. Level and stabilize the fan as necessary.
8. Do not change the fan directional switch from its normal (forward) position.
9. Install the open end of the fan pressure gauge tube on the blower door fan pressure tap.
 - a. If you are using the magnehelic gauges, zero all three of them.
 - b. If you are using a DG-3 digital manometer, record the baseline pressure reading. This reading is usually a result of stack pressure. When you pressurize the house with the blower door, make sure to bring the house to a pressure that is 50 Pascals more than this baseline pressure. For example, if the baseline pressure is -3 Pascals, pressurize the house to 47 Pascals. If the baseline pressure is -5 Pascals, pressurize the house to 45 Pascals.
 - iii. If, while performing a blower door test, you change blower rings, make sure to change the "CONFIG" setting on the DG-3 to correspond.
 - d. If you are using the DG-700 digital manometer, record the baseline pressure reading according to the manometer instruction. This reading is usually a result of stack pressure. Once you enter the baseline value into the DG-700, you can proceed with the blower door test without being concerned with the baseline value, except as noted below.

- i. If you turn the DG-700 off and on again or press the “MODE” or “CLEAR” button, you must re-enter the baseline again for a valid blower door test.
 - ii. If, while performing a blower door test, you change blower rings, make sure to change the “CONFIG” setting on the DG-700 to correspond. If you do this, there is no reason to enter the baseline again.
10. Perform a one-point test by pressurizing to 50 Pascals, or the highest house pressure possible if unable to reach 50 Pascals. Use one of the flow rings if the fan pressure is less than 20 Pascals. If wind seems to be affecting the test results, take several one-point tests and average the results.
 11. Calculate the CFM₅₀ of the dwelling by using the markings on the magnehelic gauges, digital gauges, ZipTest Pro™ software in the TI-86 calculator, or the blower door tables.

12200 Building Tightness Limit Procedures and Calculation

12210 Introduction

The purpose of the Building Tightness Limit (BTL_a) calculation is to ensure that the dwelling complies with the ASHRAE Standard 62-2001, *Standard for Acceptable Indoor Air Quality*. This Standard requires at least 15 CFM of fresh outdoor air per person and at least 0.35 air changes per hour per dwelling unit.

The BTL_a is expressed as a CFM₅₀ value, making it easy to determine whether the dwelling is tighter or looser than the BTL_a with a blower door test.

12220 General Procedure

1. Use the ZipTest Pro™ software loaded in the Texas Instruments TI-86 calculator (BTL1 program group, BTL_a program) or the MEAFF form to determine the BTL_a for each dwelling. Each dwelling unit requires a separate calculation.
2. Calculate the BTL_a before weatherization work begins. The BTL_a is a CFM₅₀ estimate that is used as an air sealing guideline; that is, if the dwelling is tightened to a CFM₅₀ value that is less than the BTL_a, the building will not comply with ASHRAE 62-2001 unless continuously operating mechanical ventilation is installed.
3. Calculate the BTL_a again after weatherization work is completed to determine if continuously operating ventilation is needed. This will be the case if the dwelling has been tightened to a level tighter than the BTL_a. Note that in some cases, dwellings need continuously operating ventilation even though they are not as tight as the BTL_a. Examples include houses with difficult moisture problems. In such

cases, install ventilation if it will help mitigate the moisture or other air quality problems.

- a. The BTLa procedure will calculate the required CFM of a continuously operating exhaust fan. The input and output data for this procedure are listed in Table 12-1. Please refer to the ZipTest Pro™ software instruction manual for detailed instructions and examples. An abbreviated definition of the BTLa data inputs is listed here for your convenience.

Note: This sizing procedure is not appropriate for balanced ventilation systems; that is, mechanically driven exhaust and supply systems.

- i. House CFM₅₀: The house CFM₅₀ after all weatherization work has been completed.
- ii. Flow exponent: Enter the default value, 0.65.
- iii. Weather factor: For Caribou and surrounding area, enter 1.00. For Bangor and surrounding area, enter 0.75. For Portland and the surrounding area, enter 0.91. There are no other weather factor values available for Maine.
- iv. House square footage: This is the occupied square feet of the dwelling. If the basement is finished and/or used as habitable space, include it in your whole house blower door test (with the door to the basement open) and include the basement as part of this square foot calculation.

Table 12-1

BTLa Procedure Inputs/Outputs	
Input Data	Output Values
a. House CFM ₅₀	1. Effective leakage area (ELA), in ²
b. Flow exponent (0.65 default)	2. Equivalent leakage area, in ²
c. Weather factor	3. Estimated natural CFM
d. House square footage	4. Estimated natural ACH
e. House volume	5. Natural CFM/occupant
f. Building height	6. ELA minimum
g. Story height	7. CFM minimum
h. Occupant count (bedrooms + 1)	8. Exhaust ventilation CFM
	9. CFM ₅₀ limit
<i>Based on ZipTest Pro™ software</i>	

- v. House volume: This is the occupied and conditioned volume of the dwelling. If the basement is finished and/or used as habitable space, include it in your whole house blower door test (with the door to the basement open) and include the basement as part of this square foot calculation.

- vi. Building height: This is the building height above grade *and conditioned* in units of feet. For buildings with varying above-grade heights (walk-out basements, etc.) use the average height of the building.
- vii. Story height: This is the height, in feet, of one story of the building.
- viii. Occupant count: For a particular dwelling, use the number of bedrooms plus one, or the actual number of occupants, whichever is larger.
- ix. After all the input values are entered, the output values as listed in Table 12-1 will be displayed. The required exhaust ventilation CFM is displayed as number 8 in the ZipTest Pro software.
- x. Once the CFM requirement for the exhaust ventilation is determined, refer Section 3380 on page 25 for fan selection and control.

12300 Depressurization Tightness Limit (DTL)

12310 Introduction

If the dwelling has conventionally vented combustion appliances, the Depressurization Tightness Limit (DTL) should be calculated before weatherization work begins.

The DTL calculation establishes a CFM₅₀ minimum, below which the backdrafting of conventionally vented combustion appliances is likely to occur. This limit provides a guideline for air sealing activities.

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

12320 DTL Procedure

1. Use the DTL program in the ZipTest Pro™ software package loaded in the TI-86 calculator to calculate the dwelling DTL.
 - a. In the ZipTest Pro™ software package, select the program "DTL".
 - b. Select a solution for "CFM₅₀".
 - c. Enter the total and actual CFM exhaust rate for all the exhausting appliances in the dwelling. You should include any appliances that are not yet installed, but will be during your 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. Refer Table 12-2 for guidance.

Table 12-2

Exhaust Appliance Nominal CFM	
<i>Appliance</i>	<i>CFM Nominal</i>
Bathroom exhaust fan	50
Kitchen range hood	100
Kitchen wall fan	250
Kitchen down-vent fan (Jenn-Air)	300 - 600
Dryer	180
Central vacuum	150
Fireplace	200 - 400
Note: Actual CFM might be significantly less than nominal – or rated – CFM.	

- d. Select and enter the appropriate building depressurization limit based on Table 12-3. If more than one appliance is located in a combustion appliance zone (CAZ), use the appliance Pascal 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 12-3

Building Depressurization Limits for Various Appliance Types (Used to calculate the Depressurization Tightness Limit)	
<i>Appliance Type</i>	<i>Building Depressurization Limit, Pascals</i>
Atmospheric water heater only	-2
Atmospheric water heater and atmospheric furnace	-3
Furnace or boiler, gas atmospheric or fan assist., Category I	-5
Oil or gas unit with power burner	-5
Induced draft appliance (fan at point of exit at wall)	-5
Direct-vent, sealed combustion appliances	-25

2. Enter the appropriate flow exponent for the house. If you do not know the actual flow exponent, enter the default value of 0.65.
3. The ZipTest Pro™ software calculates the CFM₅₀ tightness limit for combustion safety, the Depressurization Tightness Limit. Use this as a low limit to house tightening. For example, if the DTL is 1600 CFM₅₀, instruct the crew or contractor not to tighten to below 1600 CFM₅₀.

Remember, the DTL is a pre-weatherization guideline only; it must never be used to replace the worst-case draft test procedure.

12400 Air Handler Pressure Balance Testing

12410 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 draft 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.

12420 Whole House Test Procedure

1. Set up the house in winter operating mode.
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.

12430 Room-to-Room Test Procedure

1. With a pressure gauge (being careful to level and zero on 15 Pa when using a magnehelic gauge), measure the pressure difference across all interior doors. 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 mobile homes).
 - 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.

12500 Worst-Case Draft Testing

12510 Introduction

The purpose of worst-case draft testing is to ensure the proper venting of all vented combustion devices in a dwelling. This testing must always be done **after** all other weatherization work has been completed.

The Depressurization Tightness Limit (DTL) should also be calculated before weatherization work begins, when conditions warrant. The DTL is a CFM₅₀ estimate that is used as an air sealing guideline. If the dwelling is tightened to a CFM₅₀ value that is less than the DTL, backdrafting is likely to occur. The DTL must never be used as a substitute for worst-case draft testing.

The worst-case draft test measures the pressure difference between the outside and inside of the house at the combustion appliance in the combustion appliance zone (CAZ). This measurement will confirm whether there is adequate draft for the vent system of all conventionally vented combustion appliances. If a house

contains more than one CAZ, a worst-case draft test must be performed for each area.

12520 Dwellings Requiring Worst-Case Draft Testing

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

The following are *exceptions* to this requirement:

2. If the house or mobile 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 draft test does not have to be performed.
3. In apartments with no combustion appliances other than unvented or direct-vent combustion appliances, a worst-case draft test does not have to be performed.

12530 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.

12540 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 Worst-Case Draft Test form for this test. 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. Adjust the pressure gauge to 15 Pascals if using a magnehelic gauge, *when no hoses are connected to the pressure taps*. If using a digital manometer, no adjustment is needed.
8. Set up pressure hoses so that the pressure differential of the CAZ with reference to the outdoors can be easily measured. 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.
9. 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 Worst-Case Draft form.

12550 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 9 above.

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 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 draft test is performed. Refer to Section 5300 on page 35 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 (so that, for example, closing the door changes the pressure from -2 to -4), leave this door closed. If closing this door decreases the depressurization (so that, 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 worst-case depressurization; that is, the negative pressure of greatest magnitude in the CAZ with reference to outdoors.

12560 Verifying Proper Appliance Venting

1. Under these worst-case conditions, fire the combustion appliance with the lowest Btu input first to determine if the appliance is drafting properly. Measure the draft after the appliance has fired for two minutes. The draft should comply with the draft values in Table 12-4 or Table 12-5.
2. Fire all remaining appliances, one at a time, in order of input rating (smaller to larger), testing each one for draft. All appliances must achieve acceptable draft after two minutes of firing.
 - a. If the appliances vent into the same chimney flue or vent connector, test each one individually.
 - b. If the appliances vent into different chimney flues or vents, test with each successive unit running, that is, as you fire up the next appliance, allow the previous one to operate.
3. If any 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;
 - b. 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);
 - c. Duct outdoor air directly to the burner(s)' combustion supply air port; or
 - d. Increase the CAZ air volume by connecting the CAZ to the outdoors (see NFPA 54, NFPA 31, or NFPA 211).

4. If the dwelling has other combustion appliance zones, repeat the sequence of activating exhaust equipment, door closure, furnace blower activation, recording pressure readings, etc.
5. When all worst-case draft testing has been completed, turn off all exhaust equipment and return doors and combustion appliances to their previous operational settings.

Table 12-4

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

Table 12-5

Power Oil Burners	
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 or -10 to -15 Pascals

12600 Pressure Pan Testing Procedures for Mobile Homes⁸

12610 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 duct leakage directly; they infer leakage to the outdoors by reading the pressure at individual registers.

12620 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.

⁸ This section is primarily based on *Using a Pressure Pan to Diagnose Duct Leakage* by The Energy Conservatory, March 2002. This document is available on the Internet at www.energyconservatory.com/manuals.html. When you get to this Web page, find "Pressure Pan User Manual".

4. Block the filter opening by covering the filter with a plastic bag and reinserting the filter with the bag over it. This blocks the filter opening and results in a more accurate pressure pan test. When the testing is completed, make sure to remove the plastic bag from around the filter.
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.
6. Open skirting under the mobile 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 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 mobile 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 MEAFF form.

12700 Zone Pressure Diagnostics (ZPD) Testing

12710 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 two surfaces 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 not required by MSHA, but is recommended in cases where additional information is needed regarding the relative and absolute leakage of air barriers (pressure boundaries). For example, CFM₅₀ air leakage can be measured through an attic floor before and after air sealing and insulating to determine the effectiveness of the weatherization work. These ZPD procedures are most valuable on dwelling of moderate air leakage, rather than on dwellings of very high or very low air leakage.

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.

The procedures in this section describe the use of *basic* zone pressure diagnostics. There is also an *advanced* zone pressure diagnostics procedure that can make some testing procedures easier to perform, while yielding results that are more accurate. For advanced zone pressure diagnostics software programs, see <http://www.energyconservatory.com/products/products8.htm> and then go to “Free ZPD Calculation Utility (for Windows).” Also, check the “ZPDa” program in the ZipTest Pro² software package for the Texas Instruments TI-86 calculator from WxWare Diagnostics.

12720 Test Procedures

1. Use the ZipTest Pro™ software package loaded in the Texas Instruments TI-86 calculator for these tests unless instructed otherwise.
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.⁹
 - 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.
3. Identify zone types. ZPD can be done on all primary zones including attics, crawl spaces, basements, and attached or tuck-under

⁹ Advanced zone pressure diagnostics procedures do not require a house pressure of 50 Pascals.

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. For primary zone ZPD testing, perform the add-a-hole test using the ZipTest Pro™ software loaded into the TI-86 calculator. Follow these steps:
 - a. Set up the blower door for building depressurization. Use either a digital or analog manometer for the blower door test, as you would usually do.
 - b. With a separate digital manometer – let's call it the ZPD manometer – run a pressure hose from the lower tap on the left-hand channel to the zone you are testing (try to use a blue hose). Run another pressure hose from the lower tap on the right-hand channel to the outdoors (try to use a green hose).
 - c. Depressurize the building to –50 Pascals, using the digital manometer set on channel B.
 - d. On the ZPD manometer, read the left-hand channel pressure.
 - e. Measure, record, and enter the pressure from the building to the zone (BLD/ZONE $\Delta P1$).¹⁰
 - 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 (ZONE/OUT $\Delta P1$) that shows on the left-hand channel.
 - h. Determine where a temporary hole will be created – either between the building and the zone (B/Z), or between the zone and the outdoors (Z/O).
 - i. Enter the location of the created hole in the ZipTest Pro™ software – either in the building-to-zone air barrier (B/Z), or in the zone-to-outdoor barrier (Z/O).
 - j. Measure, record, and enter the size of the hole in square inches. It is best to lower the barrier $\Delta P1$ 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.

¹⁰ The terms inside the parentheses in this section are the variable names used in the ZipTest Pro™ software program.

- 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 (BLD/ZONE ΔP_2).
 - 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 (ZONE/OUT ΔP_2).
 - 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 (BLD/ZONE) CFM₅₀, the zone-to-outdoor (ZONE/OUT) CFM₅₀, and the total path (TOTAL PATH) CFM₅₀. 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.
5. For secondary zone testing:
- a. It is not necessary – or possible – to perform an add-a-hole test; only pressure testing is required. Therefore, it is not necessary to use the ZipTest Pro™ software.
 - b. If the house/zone pressure is equal to, or greater than, 35 Pascals, it is not necessary to also take a pressure reading during or after air sealing work.
 - c. If the house/zone pressure is less than 35 Pascals, continue to track progress by pressure testing during, and then after, air sealing work.

12800 Gas Range Inspection¹¹

12810 Introduction

1. 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.

¹¹ Metered testing of carbon monoxide emissions from range top burners or bake ovens is not required by this procedure; however, MSHA recommends metered testing. For an acceptable protocol for metered testing of carbon monoxide emissions in the field, see www.karg.com/rangeprotocol.htm.

12820 Inspection and Client Education

12821 A. Gas Range Inspection

1. Range-top inspection:
 - a. Inspect the range-top burner area for cleanliness. If the burners or burner area are dirty enough to adversely impact the combustion process, inform the client that the range should be cleaned to reduce the possibility of unacceptable carbon monoxide emissions.
 - b. Inspect the burners for proper alignment and seating.
 - c. All cooking vessel support grates should:
 - i. be in place,
 - ii. fit properly in the burner well, and
 - iii. be in one piece, with no broken parts.
 - d. If any of the grates are missing or in unsatisfactory condition, the client should not use the affected range burner(s) until the substandard or missing grate is replaced.
 - e. If the range-top burners are ignited with a standing pilot light, verify that the pilot is lit, is about 5/16 in length, and is soft blue in color (not yellow).
 - f. Ignite each burner for at least 30 seconds to inspect its flame for color and noise.
 - i. The flames should have sharp blue edges with orange specks rising through the flames (dust particles). Make sure there is no significant yellow at the upper tips of the flames.
 - 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), section 6.15: 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 unacceptable 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.

12822 Client Education

Educating the client is a very important. Always take the time to explain the following 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. 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 O₂; it cannot be determined by visual inspection of the flames.
5. The oven should be kept 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.

12830 Installation of Carbon Monoxide Alarms

1. Any dwelling that has a gas range must have a working carbon monoxide alarm already in place prior to weatherization, or installed during the weatherization process within or near the kitchen where the gas range is installed.

13000 Electricity Efficiency Measures

13100 Refrigerator Metering and Replacement

13110 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 the secondary refrigerator or freezer removed.
2. The client is required to give up possession of the old refrigerator. It must be removed from the premises, demanufactured, 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.¹²
3. All refrigerators considered for replacement shall be metered with the Brultech ECM-1200 device, unless there is reliable evidence that the refrigerator was manufactured in 1995 or later. 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 the Brultech ECM-1200 device; or
 - b. kWh/yr usage data from the AHAM database.
 - i. 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 13-1.

Table 13-1

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

¹² There might be other programs for refrigerator replacement conducted by organizations in Maine other than MSHA. These refrigerator replacement programs might, in practice, alter the protocol described here. One such refrigerator replacement program is that of the Maine Public Utilities Commission (PUC) which uses low-income weatherization energy auditors to test refrigerators. This PUC program demands the testing of all refrigerators, regardless of their year of manufacture. September 2004.

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. Calculation of the SIR is done with the AREFR Equation Nugget in the “Solver” section of the TI-86 calculator or with the electronic MEAFF form. In order to perform this calculation, the following values are needed:
 - a. The KWh/yr used by the existing refrigerator (kWhyrOld).¹³ This is estimated from 4.a. or 4.b., above.
 - b. Annual Average Ambient Temperature (AAAT). This is your estimate of the annual average air temperature surrounding the refrigerator. This only needs to be estimated if the refrigerator is being metered with the Brultech ECM-1200. *Note: Regardless of the actual estimated AAAT, this should be entered as 70°F if using the AHAM kWh/yr value.*
 - c. Present Ambient Temperature (PAT). This is the measured temperature around the refrigerator during the metering process. Again, this only needs to be estimated if the refrigerator is being metered with the Brultech ECM-1200. *Note: Regardless of the actual estimated AAAT, this should be entered as 70°F if using the AHAM kWh/yr value.*
 - d. The KWh/yr consumption of the replacement (new) refrigerator (kWhyrNew).
 - e. The electricity cost per KWh (CostkWh), in units of dollars. For example, 14 cents would be entered as “.14”.
 - f. The cost of the replacement refrigerator (CostNew). This amount must include refrigerator cost, any delivery charge, installation costs, and disposal of the old unit.

13120 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.
2. The meter will be connected to the refrigerator(s) for at least two hours.

¹³ The terms in parentheses in this section are the variable names in the AREFR Equation Nugget that is part of the ZipTest Pro software package loaded into the TI-86 calculator.

- a. Plan the energy analysis, entry interview, and overall visit so that the metering equipment can be connected promptly. Leave the Brultech ECM-1200 meter 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 separate instructions for the use of the Brultech ECM-1200 meter.
4. Introduce the metering process to the applicant and ask open-ended questions to help you understand how many refrigerators/freezers there are, how they are used, if they have been recently loaded, and if there are any known refrigerator/freezer malfunctions. The auditor might already have refrigerator/freezer inventory information from the intake person.
5. 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).
6. 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 must be accessible when using the Brultech wall plug adapter, the Brultech CT-60 current clip and, if necessary, a three-prong adapter.
 - c. The voltage reading (which also may be read with the Brultech ECM-1200) should be around 120.
 - d. The outlet should be properly grounded.
7. Complete the installation of the Brultech ECM-1200.
8. If more than one refrigerator/freezer is operating on the premises, try to meter both simultaneously with the Brultech ECM-1200. This device allows you to meter two appliances at once. You will probably need an extra extension cord to meter two appliances at once.
9. If it is necessary to move the refrigerator/freezer to attach your meter, be careful of the floor material. Carry a sturdy rug with you 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 PUC waiver request).

10. Open the refrigerator/freezer door(s) in order to:
 - a. Place your high/low recording remote-bulb thermometer properly.
 - 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.

- ii. Place the remote bulb of your thermometer in the freezer compartment. Make sure the bulb is suspended in air toward the back of the compartment.

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

- iii. 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°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.

- iv. 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.
11. Check the initial instantaneous kilowatt reading on your meter just after you connect your Brultech ECM-1200. 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.
12. 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.
13. 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).
14. 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 on the MEAFF 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.
15. If the refrigerator cannot be metered, document the reason in the job file. Use the AHAM database for the estimate of kWh/yr. If appropriate, multiply the annual kWh/yr consumption estimate listed by the degradation multiplier listed in Table 13-1.
 - a. These AHAM kWh/yr estimates should not be adjusted for temperature, so when using the ZipTest Pro software AREFR equation or the electronic MEAFF to calculate SIR, enter 70° for PAT and 70° for AAAT.
16. 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.
17. All replacement refrigerators shall be white in color, unless the client is willing to pay the cost difference for the color of their choice.
18. Go through the applicant education process, whether or not refrigerator(s) and/or freezer(s) are being replaced.
19. The work orders must show the manufacturer, model number, and the vendor job number.
20. The vendor should make delivery and remove the existing unit(s) within 30 days.
21. 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.
22. The vendor shall make sure that the new refrigerator is level and plumb.
23. The vendor obtains client signatures on a vendor-supplied form to verify delivery and removal of appliance(s).
24. The vendor shall properly dispose of existing appliance(s) and provide documentation to the agency regarding delivery and proper disposal. The agency will provide copies to MSHA.

13200 Incandescent Bulb Replacement with CFLs

13210 Introduction

Many new compact fluorescent lamps (CFLs) meet the stringent criteria of ENERGY STAR® for long life, start time, energy savings, color, and brightness. These new CFLs provide high quality, warm light without the flickering or humming of older fluorescent bulbs.

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.

Table 13-2

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 $\frac{1}{4}$ to $\frac{1}{3}$ that of a typical incandescent, for a given level of light output.

13220 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 “Extended MEAFF Form – Lighting Piece” to determine the “Live Savings” and “Years Payback” for each.
4. If the savings-to-investment ratio for replacement of an incandescent bulb with a CFL is one or more, the replacement should be done.

14000 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 (ACH₅₀) – 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 method used to be able to compare CO readings with varying amounts of dilution air (oxygen) mixed in. The air-free method adjusts air content (oxygen) to zero.

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.

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 – Air in the habitable space.

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).

ANSI – American National Standards Institute, Inc.

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.

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

AAMA – Architectural Aluminum Manufacturers' Association.

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.

ASME – American Society of Mechanical Engineers.

ASTM – American Society for Testing and Materials.

Atmospheric Appliances – A heating device that takes its combustion air from the surrounding room. Also, known as open-combustion heater.

- 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.

Balance Point – The outdoor temperature at which no heating is needed to maintain inside temperatures.

Ballast – A coil of wire or electronic device that provides a high starting voltage for a lamp and limits the current flowing through it.

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".

BDL – See Building Depressurization Limit.

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

Benefit-to-Cost Ratio (BCR) – See Savings-to-Investment Ratio (SIR).

Bimetal Element – A metal spring, lever, or disc made of two dissimilar metals that expand and contract at different rates as the temperature around them changes. This movement operates a switch in the control circuit of a heating or cooling device.

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

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

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

Brightness – The luminous intensity of any surface in a given direction per unit of projected area of the surface, as viewed in that direction.

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.

BTL – Building Tightness Limit calculation procedure, expressed in units of CFM₅₀, based on the American Society of Heating, Refrigerating and Air-Conditioning Engineers Standard 62-2001, *Ventilation for Acceptable Indoor Air Quality*. This method was clearly explained in an article in *Home Energy* magazine, (Tsongas 1993). The method closely follows the parameters set in ASHRAE 62-2001: For acceptable indoor air quality, 15 CFM per person (set minimum of 5 people) or 0.35 air changes per hour (ACH), whichever is greater, must be supplied by natural air leakage and/or continuously operating ventilation.

BTLa – Building Tightness Limit calculation procedure, expressed in units of CFM₅₀. It is based on ASHRAE Standard 62, Standard 119 (*Air Leakage Performance for Detached Single-Family Residential Buildings*), and Standard 136 (*A Method of Determining Air Change Rates in Detached Dwellings*). This method closely follows the parameters set in ASHRAE 62-2001: for acceptable indoor air quality, 15 CFM per person or 0.35 air changes per hour (ACH), whichever is greater, must be supplied by natural air leakage and/or continuously operating ventilation. However, the BTLa method uses different calculation methods – based on ASHRAE 119 and 136 – than the BTL method to arrive at the final tightness limits.

Btuh – British thermal units per hour.

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

Building Depressurization Limit (BDL) – BDL 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 the BDL, it has the potential to backdraft, causing a hazardous condition for the occupants. The BDL for furnaces and boilers is often -5 Pascals and for stand-alone natural draft water heaters, -2 Pascals. Field studies have been done to determine the negative pressure at which these appliances will begin to backdraft.

Building Science – An 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.

Building Tightness Limit – A general term for a house-tightening limit, expressed in units of CFM₅₀, used for ensuring adequate indoor air quality for the house occupants. Two building tightness limit procedures used in the Maine Weatherization Program are BTL and BTLa.

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 (CO₂) – 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.

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.

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

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

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.

Color Temperature – A measurement of the warmness or coolness of a light source in the Kelvin temperature scale.

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

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.

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

Compressor – A motorized pump that compresses a gaseous refrigerant and sends it to a condenser where heat is released.

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 envelope or shell. It includes both habitable space and occupiable 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.

Conventionally Vented Combustion Appliance – Combustion appliances that are characterized by atmospheric burners or natural draft. Sealed or direct-vent appliances are not conventionally vented.

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 prep 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.

CFM₅₀ – The number of cubic feet per minute of air flowing through the fan housing of a blower door when the house pressure is 50 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.

Demand – The peak need for electrical energy.

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 CFM₅₀, to estimate the building tightness level at which combustion appliances might backdraft when the house is under conditions of worst-case depressurization. A BDL must be selected for the calculation of the DTL. The DTL sets a low limit for air sealing that may or may not be lower than the building tightness limit for the same house.

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 – Appliances that are constructed and installed so that all combustion air is taken directly from – and the flue gases are vented directly to – the outside.

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.

Draft Diverter – A device built into an appliance or made a part of the vent connector for an appliance that is designed to: 1) provide for the ready escape of flue gasses from the appliance in the event of no draft, backdraft, or blockage beyond the draft hood, 2) prevent a backdraft from entering the appliance, and 3) neutralize the stack effect of the chimney or gas vent upon the operation of the appliance.

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 in dry climates that cools the incoming air by the evaporation of water.

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 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.

Feeder Wires – The wires connecting the electric meter and main switch with the main panel box indoors.

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.

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 Joists – The horizontal framing members 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.

GAMA – Gas Appliance Manufacturers' Association.

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

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.

Hazardous Material – A particular substance that is considered a danger to the client/crew/contractor.

HHS – United States Department of Health and Human Services.

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

Heat Rise – In a furnace, the number of degrees of temperature increase that air is heated as it is blown over the heat exchanger. Heat rise equals heated air temperature minus air return temperature.

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 -

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.

IAQ – Indoor Air Quality

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

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.

Ingestion – Ingestion is the process by which a substance enters the body by swallowing. The best defense against ingesting harmful materials is to wash hands before eating or putting fingers in the mouth, keeping hazardous materials out of reach of small children, and guarding against hazardous materials splashing into your mouth.

Inhalation – Inhalation is the process by which a substance is breathed into the body in the form of a gas, vapor, fume, mist, or dust. The best defense against the inhalation of hazardous substances is to use a proper filter to remove these contaminants before they enter the body, and to prevent the creation of dust, if possible.

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

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 pre-1978 homes when the weatherization work will disturb more than 2 square feet of painted surface in an interior room, 10% of a small component such as a baseboard or door casing, and/or when the work will disturb more than twenty square feet of painted exterior surface.

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

Living Space Return System – In a mobile 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 mobile home belly.

Low-Water Cutoff – A float-operated control for turning the burner off if a steam boiler is 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 -

MSHA – 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.

MEADOW96 – The DOE-approved waiver energy audit used by the Maine Low-Income Weatherization Program.

MEAFF – Maine Energy Auditor Field Form. This form, which is occasionally updated, is used during the initial energy audit on a dwelling. It includes a checklist of interview questions regarding client health and dwelling condition; calculation sections for the energy index, blower door test, and ventilation; a section for insulation inventory and recommendations, etc.

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

NWMA – National Woodwork Manufacturers 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 -

O₂ – 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.

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.

Overall Tightness Limit (OTL) – The OTL is expressed in units of CFM₅₀. The OTL is the higher of the building tightness limit or the Depressurization Tightness Limit. For example, if the building tightness limit is 1300 CFM₅₀ and the DTL is 1400 CFM₅₀, the OTL for the house is 1400 CFM₅₀, satisfying both the building tightness limit and the DTL.

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. 2.5Pa = 0.01 inches 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.

Pilot 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 lath 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.

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.

Provider – Either a grantee or contractor.

- 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.

Rated Ventilation – A ventilation system that has been designed and installed under the guidelines established by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard for Acceptable Indoor Air Quality (Standard 62).

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.

RCS – Residential Conservation Service Program.

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.

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.

$$SIR = \frac{\text{Annual Savings from Measure}}{\text{Cost of Measure}} \times \text{Discounted Life of Measure}$$

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.

Sequencer – A bimetal switch that turns on the elements of an electric furnace in sequence.

Service Wires – The wires coming from the utility transformer to the service equipment of the building.

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 job 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.

SMACNA – Sheet Metal and Air Conditioning Contractors' National Association.

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.

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 mobile 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 – The temporary flow of combustion gases from a dilution device.

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 -

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.

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 that retards the passage of water vapor.

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

Vapor Retarder – A vapor barrier.

Vaporize – To change from a liquid to a gas.

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.

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.

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 Draft 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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