West Virginia Weatherization Field Standards

and

Best Practices

April 2012
Low-Income Weatherization Assistance Program

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Introduction

The West Virginia Weatherization Field Standards and Best Practices provide guidelines to local administering agencies 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 having a full understanding of the State's Weatherization Field Standards and Best Practices.

The objective of this document is two-fold. First, it serves to define the appropriate application of weatherization measures for each residence served. The document 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 Field Standards and Best Practices 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, often referred to as "best practices." 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 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 Governor's Office of Economic Opportunity 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 Assistance Program has changed substantially, both technically and administratively, since its inception over three decades ago. The weatherization process continues to evolve in response to changes in funding, weatherization technology, program rules, and administrative personnel. The West Virginia Weatherization Field Standards and Best Practices will be used to implement and document these changes as they occur.

From time to time, these Standards may be amended and/or revised to reflect changes in state or federal regulations, advances in technology, and/or innovative approaches to weatherization. These Standards are organized to easily accommodate changes.

1 Administrative, Scope, and General Requirements

1.1 Effective Date

1. All weatherization measures performed or completed on or after the date specified in the Agency Weatherization contract will comply with these Standards.
2. All dwelling units completed after the effective date, April 1, 2012, will comply with these Standards.

1.2 Scope

The goal for the West Virginia Weatherization Assistance Program (WAP) is: "To reduce heating and cooling costs for low-income families, particularly for the elderly, people with disabilities, and children, by improving the energy efficiency of their homes and ensuring their health and safety."

1. The Weatherization Field Standards and Best Practices will apply to all local administering agencies providing Weatherization Assistance Program (WAP) services.
2. The Weatherization Field Standards and Best Practices provide guidelines for the installation of energy conservation measures and repairs. Materials and measures that are allowed or not allowed will be specifically designated.
3. Items designated as "preferred approaches" are not required, nor are they mandatory. Agencies will be in compliance with the Weatherization Field Standards and Best Practices 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 (SIR). Any agency wishing to deviate from the "preferred list" must first request permission from GOEO detailing their rational for the change. 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.
4. These Standards are not intended to abridge safety, health, environmental, or local codes or other ordinances. Such requirements, if more stringent than these, will apply; if these Standards are more stringent, the Standards will apply.
5. All questions concerning the content or implementation of the Standards should be directed to the West Virginia Governor's Office of Economic Opportunity (GOEO).
6. These Standards are intended to be utilized in conjunction with 10 CFR Part 440, the DOE Weatherization Regulations, and the WV WAP Finance and Administration Manual.

1.3 Enforcement

Continued agency inability and/or refusal to comply with these Standards are grounds for the Governor's Office of Economic Opportunity to suspend, terminate, or otherwise apply special condition(s) to the agency's current contract to provide weatherization services.

1.4 Amendments to Weatherization Field Standards and Best Practices

1. From time to time, these Standards may be amended and/or revised by the West Virginia Governor's Office of Economic Opportunity to reflect changes in state or

federal regulations, advances in technology, and/or innovative approaches to weatherization. The GOEO encourages agencies 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.

1.5 Weatherization Standards Waivers

1. Deviations from the Weatherization Field Standards and Best Practices require a waiver from the GOEO Weatherization Program Director prior to the expenditure of funds. Work may proceed after verbal authorization by the GOEO Weatherization Program Director. An electronic or hard copy documenting authorization will be forwarded and kept on file.
2. For example, waivers may be granted:
    a. If a client/occupant refuses to allow a certain measure to be completed and this measure has a higher priority or Savings-to-Investment Ratio (SIR) than the remaining measures. Agency personnel must document the reason the work was not performed.
    b. To convert water heaters or heating systems to a different fuel type.
        i. Gas water heaters may be replaced with electric water heaters if it is necessary to correct an unsafe or code compliance situation.
        ii. Clients have the option of declining or waiving a conversion for personal reasons. For example, if a conversion requires that a new venting system be run through finished space and the client does not like the appearance, the client may decline the conversion.
        iii. Agencies must first educate the client regarding the advantages and disadvantages of switching fuels. If the client declines the conversion, they must sign a statement in the client file waiving the conversion.
        iv. Fuel-switching costs should be analyzed for cost-effectiveness using the approved audit.
        v. Fuel conversions must be completed by qualified personnel in compliance with applicable building codes.
        vi. Fuel switching must be considered on a case-by-case basis. Fuel switching must be approved in writing by GOEO and documentation retained in client file.

1.6 Deferral of Weatherization Based on Site Conditions

The primary goal of the Weatherization Assistance Program is to save energy. In some instances, a dwelling may be structurally unsound or otherwise unsuitable and not adaptable to weatherization without repairs beyond the scope of the program. While every effort should be made to secure resources to make those repairs so weatherization can be done, program services may have to be deferred until repairs are made or a condition is remedied.

1. Conservation measures and associated repairs may be omitted if the work cannot be completed because of health, safety, local codes, or other technical reasons. The following are examples of acceptable grounds for a waiver:
    a. Risk to client or agency staff due to health or safety risks such as fire, explosion, bodily harm, unruly pets, harmful combustion by-products, electric shock, friable asbestos, severe unsanitary conditions, severe structural damage, or height clearance.
    b. Risk to agency staff due to drugs or drug paraphernalia in accordance with established agency policy.

2. Deferrals do not require State approval, but a brief explanation must be documented in the client file. In addition, the client must be informed in writing if they are eligible for program services but the dwelling cannot be weatherized due to site conditions.
3. For further details on the policy regarding deferral due to site conditions, please refer to Section 4.25 on page 54.

1.7 Weatherization Tagging Procedure

The purpose of this tagging procedure is to establish a standard policy throughout the West Virginia Weatherization Program network of physical identification of weatherized homes. This procedure is required by the "Reweatherization" Policy of the Department of Energy.

Failure to adhere to this policy could result in the dwelling not deemed as a "completion" and in turn, all associated costs would be disallowed. Therefore, the agency would not be reimbursed for the cost of the weatherization work.

The following procedures are required:

1. Agencies are required to place standardized tags provided by the GOEO on specified areas of dwellings after completing the weatherization process. After the tag has been initialed by the quality control inspector, as indicted below, a clear plastic protective cover will be placed over the tag.
2. The tags will include the following for identification purposes:
   a. Agency name.
   b. "WV Weatherization Assistance Program."
   c. Sequential tag number.
   d. "DO NOT REMOVE" indication.
   e. Initials of the agency quality control inspector and the date of the quality control inspection, written with permanent marker.
3. Agencies must place these tags in two locations on the dwelling:
   a. On the inside cover of the electrical panel/box or other place on the panel if the cover is missing.
   b. For site-built homes; on an attic rafter or beam within sight of the attic hatch.
   c. For mobile homes; on the frame of the mobile home where the waterline enters the dwelling.
4. For verification purposes, agencies must include photographs of the tag placements in the corresponding client file in the event the tag were to fall off or be removed.
5. Agencies must enter the tag number for tracking purposes into the data management system for each dwelling.

1.8 Historic Preservation Requirements

This section ensures compliance with the National Historic Preservation Act, DOE Weatherization Guidance, and the WV State Housing Preservation Office (SHPO) agreement.

The GOEO Weatherization Program office will, as required, maintain a "Historic Preservation Review Inventory" of all weatherization structures submitted for Historic Preservation review. This inventory will be maintained in the WV WAP Information Management System's Customer File and will be available for review by DOE, WV SHPO, or other bodies as requested.

1. WVSHPO requires that every structure 45 years old or older (mobile homes are not included) that is estimated for weatherization assistance must have submitted the following, and received approval from GOEO WAP Historic Preservation Specialist, before any weatherization work can proceed. Agencies are required to submit/attach the following in the WV WAP Information Management System Customer File before any federal dollars are spent to install materials on the home:
   a. A completed and signed two-page WV WAP "Historic Preservation-Review Data Sheet" (HP-RDS); which includes the Structure Build Year date, and a detailed description of any proposed Work Order activities which fall outside the "WUE-106" (Weatherization Undertakings Exempt from Section 106 Review) two-page document that is a part of the WV SHPO-GOEO Letter of Agreement.
   b. A digital picture of the structure from the public right of way view.
   c. A map (WV SHPO GIS) denoting the topographical street view location of the structure.
   d. Approval in the WAP Information Management System, under the "Action Plan" steps—denoting "HP Review Data Sheet Approved" and "date" —with approval by the GOEO WAP Historic Preservation designated staff reviewer.

No federal funds can be expended on weatherization structures 45 years old or older until Historic Preservation Review and Approval is noted in the customer file of the Information Management System.

If an agency submits a Historic Preservation review request for a structure that is located within a Historic District, or is listed on the National Register of Historic Places, or has other uniquely sensitive historic significance, the GOEO WAP Historic Preservation Staff must contact the WV SHPO for review before any approval is given. If a project is determined to need to be reviewed by WV SHPO, no work can be performed with federal dollars until SHPO finds no adverse effect in a final Section 106 determination or any adverse effect is resolved to the SHPO's satisfaction.

1.9 Contractor Requirements

The use of contractors in the West Virginia Weatherization Assistance Program is an acceptable means for performing measures that are beyond the expertise of agency personnel or in an effort to meet production requirements. Agencies must ensure that contractors are licensed and bonded, have 1 million dollars in aggregate liability insurance, have industry recognized certifications, and meet Davis-Bacon requirements as well as documentation for verification. Agencies are responsible for checking suspension and debarment lists to assure contractors are permitted to do business in West Virginia.

All contractor installed measures must conform to all applicable local, state, and federal codes or to the manufacturer's recommendation, whichever is the most stringent. Contractors must guarantee all workmanship and materials for a period of one year after they have received payment in full for a job. The contractor is responsible for the removal of any equipment and all associated refuse and must dispose of it in accordance with all applicable laws. Payment in full shall not be offered until the agency quality control inspector verifies that all requirements of the West Virginia Installation Standards and Best practices have been met. All invoices submitted for payment must be itemized to include, at a minimum, the cost of labor and materials. Agencies are responsible for compliance to guidelines and inspection procedures prior to reporting jobs as a completion. The GOEO will provide additional guidance as needed.

1.10 Additional Guidance

1.10.1 Required Client File Documentation

Documentation for each completed client file must contain:

1. Central Customer Report with signed disclaimer which includes homeowner's permission to work on the dwelling and fuel bill release authorization.
2. Income Verification with client's statement of income, back-up documentation, and re-verification, when necessary. Refer to WPN 10-1 or WPN 10-18 for further guidance on definition of income.
3. Owner Agreement Form for rental unit (if applicable).
4. Residential Audit Tool/Work Order detailing all aspects of the job concerning the actual weatherization of the home, including the job orders, actual material used and cost, and a home inspection. This document must be signed by the auditor and crew supervisor.
5. Confirmation of Receipt of Lead Pamphlet (if applicable) certifying that the EPA booklet "Renovate Right: Important Lead Hazard Information for Families, Child Care Providers and Schools" was given to the client prior to the start of work in homes built before 1978. Clients must receive this booklet at least seven days before work begins if physically delivered. If mailed, booklet must be mailed fourteen days before work starts.
6. The Energy Saver's Partnership Plan and Energy Education Certification Form documenting the energy education provided by the agency to the client.
7. Mold and Moisture Assessment Findings Form to assess existing moisture and/or mold problems in the dwelling.
8. Hold Harmless Statement (if applicable), to document existing or potential health and safety problems that the Weatherization Assistance Program will not be able to repair.
9. Carbon Monoxide Warning Statement (if applicable), to document high levels of carbon monoxide found when testing combustion appliances.
10. Solid Fuel Inspection Report for each solid fuel appliance.
11. Photos to document any health and safety concerns, pre-work and post-work photos of when window(s) or door(s) are replaced, Lead safe work site and postwork inspector verification of Insulation and air sealing of closed knee walls. For the details of lead safe work practices, refer to Section 4.14 on page 40.
12. A signed Post-Work Inspection report indicating that all work has been performed in accordance with the West Virginia Weatherization Field Standards and Best Practices, all safety tests have been correctly documented and all required documentation is in client file. This report must be part of the client file and signed by estimator/auditor and crew supervisor.
13. Copy of Historic Preservation documents to include WAP Undertakings Exempt from Historic Preservation Section 106 Review and WV WAP Historic Preservation Review Sheet, if applicable.
14. Daily Combustion Safety testing form.
15. Documentation of justified deviation from Work Order (if applicable).
16. As GOEO moves forward, the WAP electronic management system will be utilized as a substitute for some current written documentation. GOEO will provide the necessary guidance as the WAP electronic management system is developed.

17. A completed written Job Book. An electronic management system copy may be requested by GOEO monitors on site, and/or utilized for desktop monitoring purposes.

1.10.2 General Requirements – Quality Control

1. Each job must have an accurate work order generated by the auditor, either manually or with the Residential Audit Tool. Documentation must be placed in the client file. See Chapter 3 on page 9 for a description of Residential Audit Tool (RAT).
2. The agency must conduct a thorough inspection of each completed unit before it is reported to the State as a completed dwelling unit. Final inspections must be performed by certified quality control inspectors. Certified quality control inspectors must ensure that all work was completed in accordance with the Weatherization Field Standards and Best Practices, that documentation has been completed and is in the client file, WAP information management system and all materials and installation have been accounted for and documented properly, and that structure adheres to the weatherization tagging procedure (refer to Section 1.7 on page 3). A copy of the Post-Work Inspection Form must also be in the client file.
3. All installations must be performed in a neat and professional manner.
4. At no time during the job will the crew store any materials and tools in living areas of the dwelling. Tools and materials will be placed in proper storage chests. Materials may not be left on the client's property. Trash generated by crews, or from the job, must be removed from the client's property and properly disposed of.
5. All materials being installed by the crew will be installed with efforts to match the existing trim or finish material that is adjacent to the new installed trim. The client should be aware of any changes in trim.
6. Required building permits, electrical permits, plumbing permits and other permits required by local or State authorities will be obtained by the agency Permits must be obtained prior to commencement of work and copies of permits must be provided to the owner.
7. A copy of all manufacturers' warranties will be included in the final client file.
8. All repair work will conform to the local building codes when applicable.

2 Weatherization Personnel

2.1 Program Personnel Core Competencies

The competencies or skills that a West Virginia weatherization worker should possess depend on their position. For example, an energy auditor must conduct diagnostic testing that may not be required of a retrofit installer technician. An installer must acquire additional skills to become a crew leader, and still more to become an energy auditor. These increasing levels of competency provide a professional development path for agency personnel.

Definitions for Core Competencies

1. *Competency* means the possession of a minimum level of knowledge and proficiency required to collect appropriate information, make informed decisions, and physically perform the needed actions to deliver the high-quality weatherization service.
2. *Possess a working knowledge of* means to:
   a. Know how a particular topic effects the weatherization process;
   b. Have the relevant information committed to memory or be able to locate it in readily available sources; and
   c. Use this knowledge to make informed decisions and guide weatherization work.
3. *Demonstrate the ability to* means to:
   a. Physically conduct a test, procedure, or technique on an actual house, a prop, or in a training laboratory in the presence of someone qualified to assess the particular competency.

All weatherization staff must possess the following basic skills:

1. Ability to read and write legibly;
2. Basic verbal and written communication skills;
3. Basic construction knowledge; and
4. Basic math skills.

Note: Core competencies and training requirements will be defined at a later date in a separate document.

3 Pre-Weatherization Inspection, Priority Lists, and Energy Audits

3.1 Introduction

The auditor plays a critical role in the success of the effectiveness of the weatherization measures conducted on the home by identifying the most effective measures for energy savings. The auditor must provide sufficient information for the crew to work on the home, such as materials needed for the job, measures to be taken, and any specific problems or conditions the crew may encounter.

Measures to be taken on the home are determined by visual inspections, diagnostic testing, practical considerations, measures priority lists, calculation of savings-to-investment ratios, and the Weatherization Field Standards and Best Practices.

3.2 General Requirements

1. Each client file must have an accurate Residential Audit Tool (RAT)/Work Order generated by the auditor. An acceptable work order is one for which all installed energy-saving weatherization measures are on the appropriate priority list or have a Savings-to-Investment Ratio (SIR) of 1.00 or greater.
    a. All energy-saving measures must be considered and ranked in order of descending priority list category or SIR. Installing a measure from a lower priority list category without first installing all measures from a higher priority list category, or installing a lower SIR measure without installing others with greater SIR is forbidden; in other words, measures may not be skipped.
    b. It is not permissible to omit measures vital to the success of the weatherization job. For example, it is not permissible to partially insulate a dwelling because of budget constraints. All mandatory measures must be performed.
2. The work order must clearly itemize the work to be completed by the agency crew. 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. Location of measured to be installed or treated.
    e. The method of insulation installation with the proposed amount, type, and R-value of the insulation to be installed.
    f. The type of vapor retarder and attic venting to be installed, if any.
    g. Details of any warranties on materials used in the home.
    h. Required signatures.
3. Required Historic Preservation (HP) documents to include Section 106 Checklist and West Virginia WAP Historic Preservation Review Data Sheet (HP-RDS), if applicable. Please refer to Section 1.8 on page 3 for details.
4. Each home must be inspected for a weatherization tag to determine if structure was previously weatherized. Please refer to Section 1.7 on page 3 for more details.
    a. Tags must be placed in two locations on a dwelling:

i. On the inside cover of the electrical panel/box or other place on the panel if the cover is missing; or
ii. For site-built homes; on an attic rafter or beam within sight of the attic hatch.
iii. For mobile homes; on the frame of the mobile home where the waterline enters the dwelling.

3.3 Auditing Tools and Equipment

1. Residential Audit Tool (RAT).
2. Weatherization Assistant audit tool (NEAT and MHEA).
3. Approved blower door.
4. Digital manometer.
5. Approved carbon monoxide measurement instrument.
6. Portable combustion analyzer such as Bacharach Fyrite Pro, Insight, or PCA2.
7. Electronic combustible gas detector.
8. Digital auto-ranging clamp multi-meter with milliamp sensitivity.
9. Weatherization Assistant software installed on a computer with current cost data (preferred in field but in office also acceptable).
10. Digital camera.
11. Flashlight and mirror.
12. OSHA-approved respirator.
13. Toolbox with miscellaneous tools.
14. Stepladder or telescoping ladder.
15. Extension cord.
16. Battery powered drill with appropriate bits.
17. Infrared Camera.
18. Personal CO Monitor.
19. Non-contact voltage tester.
20. Exhaust fan flow meter.
21. Borescope.
22. Utility light.
23. Smoke pencil/puffer.
24. High-temperature sealant.
25. Smoke pump and filter paper for testing oil-fired combustion appliances.
26. Non-contact voltage tester.
27. “Plug-load” electric meter.
28. Appropriate hand tools.

3.4 Audit Requirements

1. The audit must include as a minimum:
   a. Information about the existing condition of the dwelling and its mechanical systems;
   b. Evaluation of Historic Preservation (HP) requirements to include Section 106 Checklist and West Virginia WAP Historic Preservation Review Data Sheet (HP-

RDS), if applicable. Obtain documented approval when required. See Section 1.7 on page 3 for details.

c. Diagnostic tests, including combustion appliance analysis and blower door testing;
d. Health and safety problems, including possible lead-based paint, moisture and/or mold, electrical problems, signs of rust and corrosion on combustion appliances;
e. Existing insulation levels;
    i. For mobile homes, drill 4" inspection port at an inconspicuous location towards center of mobile home to evaluate existing insulation levels for Priority List recommendation. Cover the drilled hole with plastic plug to allow for quality control inspector evaluation.
f. Conditions the work crew needs to know and prepare for in advance;
g. Dwelling evaluation, considering existing conditions for energy savings opportunities and related health and safety problems;
h. Identification of appropriate air and thermal barriers;
i. Assessment of priority lists and measures to be taken;
j. NEAT/MHEA audit when required.
k. Outline of health and safety considerations;
l. Strategy for weatherizing the dwelling.

2. Work orders must effectively communicate to the crew sufficient information on the home and measures to be taken. The work order should include:
    a. Particular problems or considerations crew needs to know in advance;
    b. Total costs and for all proposed measures;
    c. Estimate of the time to complete the work;
    d. Analysis of warehouse inventory as it relates to the job; and
    e. Analysis of whether utility funds will be used for certain measures.

3.5 Recommended Auditing Procedure

Every auditor will develop their own style of conducting a weatherization audit. The following steps outline a basic approach and tips that an auditor may use as a guide to effectively assess a housing unit for weatherization.

3.5.1 Preparation

1. Select the potential job to be audited. If possible, try to keep them close together to reduce travel time between homes.
2. Make sure client file is up to date. You may need to pick up additional income verification or other forms, utility bills, etc.
3. Know your agency's partnership programs such as home repair, utility or others that might assist if additional funds are required for the job.
4. Call the client to make an appointment. Verify address and directions. If you are still unsure of the client's location, use internet directions. Be sure to ask the client not to operate their fireplace or other solid-fuel appliances the day of the audit (if possible), so that the blower door test can be safely done.

3.5.2 Audit Process – Working with the Client

1. Don't get discouraged before you have even knocked on the door. That big old two-story frame in poor condition can dampen anyone's spirit.
2. Introduce yourself and smile. Explain to the client why you are there and what you will be doing. Give them a business card or show your agency identification. You may be the first representative of the weatherization program the client has met.
3. Small talk, even about the weather, helps to break the ice. Ask about the family pictures on the wall.
4. Sell yourself and the program. This is a crucial element of the audit process. The client is not well acquainted with you and has little, if any, idea what you and your crew are going to be doing to their home.
5. Act in a professional manner. Your behavior will influence how the client will prepare for the weatherization work, respond to the crew, respond to energy education, and view the agency and program. Tell the client they are welcome to observe your audit process if they choose. If they do, you have just accomplished two objectives. First, the client will be more at ease because of your openness. Second, you probably just generated another application.
6. Involve the client. Explain that you will need to be "poking around" the house in the basement, attic, closets, bedrooms, and bathrooms. If possible, take the client through the home with you while you gather your information. Nobody knows the house better than the client.
7. Don't rush your audit. Take your time and think things through. The advice and decisions you make may have a huge impact on the client's life. You should have a cell phone in case you need to postpone or cancel the next scheduled audit.
8. Know your crew's strengths and keep them in mind. The job may require the special talents of certain individuals or crews.
9. Don't make promises you are not sure you can keep. If you are not sure of a measure, tell the client: "Let's let the crew take a look at it."
10. Perform an exit interview with the client. Explain what you found, what measures may be done, and an approximate date when they can expect work to begin. Communicate clearly anything that they may need to do before the crew can do their work, such as removing clutter from the attic. Ask them if they have any questions.
11. Tell the client that if they know of anyone else that needs weatherization help to get in touch with you.
12. If job is deemed a deferral explain reasons to client and follow up with a deferral letter. Refer to Section 1.6 on page 2.
13. Collect any missing paperwork or signatures from the client.
14. We suggest that agencies utilize a form to inform clients that once work has been completed and approved by the quality control inspector, the agency will not return with the exception of a callback from a state monitor.

3.5.3 Estimation Process – Gathering Necessary Information

1. Utilize the required Residential Audit Tool to guide the auditing process, document findings.
2. The audit should begin at the exterior of the structure to identify any potential health and safety problems or issues regarding structural integrity.

3. Make a visual assessment of the heating unit—the type, make, venting, condition, fuel type, and safety switches.
4. Document any findings on the proper forms. Refer to Section 1.10.1 on page 5 for a list of the required forms.
5. Depending on the season, decide when to conduct the heating system efficiency test. In summer, do this first and then operate the blower door to cool down the house. In winter, do the reverse. Be sure to check all health and safety devices and test the carbon monoxide level of all combustion appliances.
6. Inspect the rest of the house—bathrooms, attic, kitchen, bedrooms, closets, and crawl spaces. Be observant throughout this process. Look for obvious air leaks as well as health and safety issues. Check the ground fault circuit interruption (GFCI) outlets, venting equipment, look for moisture problems, etc.
7. The pressure boundaries and thermal boundaries of each dwelling must be determined during the inspection.
8. All building cavities that define the thermal enclosure between the conditioned space and outdoors must be inspected and measured for existing insulation R-values, structural integrity, and the need for repairs.
9. The field inspection must identify the most appropriate methods for:
    a. Reducing air leakage and convective bypasses; and
    b. Increasing the insulating value of thermal boundaries, when appropriate.
10. As you move through the dwelling, make sure it is set up for the blower door test. Close windows and exterior doors; deactivate vented combustion appliances, etc.
11. Conduct a blower door test unless there are problems such as friable asbestos or an operating solid-fuel appliance.
12. Walk around the house with the blower door running and check for air leakage. Do not forget to check for leaks in basements that are within the thermal enclosure of the dwelling.
13. Perform other required tests, such as zone pressure diagnostics, and document the findings.
    a. ZPD testing is required by the West Virginia GOEO Program in all cases where additional information is needed regarding the relative and absolute leakage of air barriers (pressure boundaries), including attics and attached or tuck-under garages.
14. Measure the perimeter of the house from the inside or outside. If it is a complicated house, you may want to do this at the beginning of your audit and make your sketch of the floor plan so that you are oriented when inspecting the interior of the house.
15. Use a digital camera to photograph the heating system and any areas of the house that may present a challenge. These images can be a valuable reference when you are back in the office writing up the job. It is always a good idea to take photographs of moisture problems, date them, and include printed copies in the client file.
16. Put personal and household items back where you found them. Relight any pilot lights that may have been extinguished during the blower door test.
17. Look over your paperwork for a few minutes in the car before you drive away to be sure you have collected all the information you need. Organize your notes. Be sure you have done everything you need to on-site.
18. Utilize digital photographs to document any health and safety problems, structural concerns, window replacements or measures that will require clarification to crews.

Any window replacements must have a digital photo of existing window placed in the client file.

3.6 Work Order Process

1. Write up a work order of the most cost-effective measures for the home. Write or type the job order legibly and describe the work requests clearly and specifically.
2. Analyze warehouse stock and whether any materials need to be ordered.
3. Work up the audits as soon as possible. The longer they sit on your desk, the more you forget.
4. Give the crew the work orders for the job and discuss the work with them. Show the crew pictures of the job. Discuss your possible solutions and encourage their comments. Let the crew members know you are open for suggestions.
5. If possible, visit the crew while the work is in progress and try to conduct the quality control inspection the last day of the job.
6. Sign work order.

3.7 Energy Audit Procedures

As allowed by DOE regulations, the West Virginia Weatherization Assistance Program utilizes priority lists for comparable dwelling units that do not have unusual energy-consuming characteristics. The priority lists are developed by conducting site-specific energy audits of a representative group of comparable dwelling units.

In both priority lists, measures are listed in order of priority, according to their cost-effectiveness. Weatherization agencies must install measures higher on the list before those lower on the list unless specific health and safety measures take precedence or specific measures are not applicable to that particular dwelling. In either case, the reason a measure is skipped must be documented. Skipping measures is discouraged.

These priority lists will be periodically updated by the West Virginia GOEO, submitted to DOE for approval, and then distributed to the agencies.

West Virginia WAP uses the Weatherization Assistant software as its energy audit tool. The Weatherization Assistant energy audit software was developed by Oak Ridge National Laboratory specifically for the use for the Weatherization Assistance Program. There are two components to the Weatherization Assistant software: the National Energy Audit Tool (NEAT) for single-family site-built and multifamily buildings (individually heated, less than five stories and 25 units in building) and the Manufactured Home Energy Audit (MHEA) for mobile homes.

The agency auditor, coordinator, and quality control inspector must have the ability to run and evaluate outputs in the Weatherization Assistant Tool. Measures must be installed in the order listed unless specific health and safety measures take precedence or specific measures are not applicable to that particular dwelling. In either case, the reason a measure is skipped must be documented.

3.8 Priority List for Site-Built Homes

The Site-Built Priority List is representative of the most cost effective general measures in order of SIR. It allows the Auditor and Crew Supervisor latitude to make energy efficiency related judgment

calls while on the job. Measures should be installed in the order listed unless specific documented health and safety measures take precedence.

Structures that fall outside normal parameters in weatherization will require a NEAT audit to evaluate cost effectiveness of measures. Audits are also required to prove the cost effectiveness of windows and doors, HVAC efficiency and refrigerator replacements.

It is very important that any judgment calls be based upon cost effectiveness considerations or verified with a NEAT audit with a savings-to-investment ratio (SIR) justification of greater than 1.

General Measures	Detailed Measures
1. Heating System Clean and Tune	• Mandatory measure (unless system is being replaced.) • Document all mandatory health and safety tests.
2. Air Sealing	• Mandatory measures. • Use blower door and zone pressure diagnostics to guide air sealing. • Ducts must be sealed as per blower door guided and duct diagnostic standards. Seal ducts only if they are outside thermal enclosure. • Home must be sealed at least to upper limit of the target range and any other significant or obvious air leaks. • Seal all major bypasses and key junctures. • Attics/ceilings must be sealed prior to installation of attic insulation. • Utilizing blower door guided diagnostics, seal floors that are considered part of the thermal boundary.
3. Duct Insulation	• After sealing ducts outside the thermal enclosure, insulate the same ducts.
4. Attic Insulation	• Mandatory measure: Insulate attics to R-38 if existing insulation is R-0 to R-19. • If there is even and consistent existing insulation of R-20, additional insulation is not required. • Mandatory measure: Dense pack knee walls with insulation or use R-19 fiberglass batt insulation. • Seal applicable key junctures in knee wall areas. • Existing attic insulation evaluation must be based on consistent coverage (R-value and depth). Any existing voids will decrease the overall R-value of the attic.

General Measures	Detailed Measures
5. Sidewall Insulation	• Mandatory measure: Dense-pack wall cavities to R-13 or maximum structurally allowable.
6. Floor Insulation	• Mandatory measure if there is an open foundation and no existing insulation. • Insulate floors that define heating enclosure to R-19 (if none existing). • Do not insulate floors over conditioned areas (areas within the thermal/pressure enclosure).
7. Heating System Replacement	• Case-by-case consideration. Replacement justification must be documented. • A NEAT audit must be run to determine if the SIR is greater than 1 on all units where replacement justification is based on efficiency. • Must replace with 90+ high efficiency forced-air unit or highest efficiency possible space heater.
Baseload Measures	
• Water Heater Insulation	• Mandatory measure. • Insulate tanks with less than R-11 existing insulation (unless added insulation will void manufacturer's warranty). • Insulate tanks to a minimum of R-8 tank wrap.
• DHW Pipe Insulation	• Insulate the first 6 feet of cold and hot water pipe. • Insulate all water pipes that are outside of the thermal enclosure.
• Refrigerator Replacement	• Mandatory measure for DOE/DHHR if SIR is equal to or greater than 2. • Mandatory measure if paid by electric utility EEP and SIR greater than 1.5. • Optional measure if affordable for DOE/DHHR if SIR greater than 1.
• CFLs	• Replace if bulb is on more than 1 hour per day.
• Shower Heads	• Replace, with client permission, if existing flow is greater than 3 gallons per minute.
Health and Safety	
• Heating System Replacement	• Case-by-case analysis. • Heating systems with non-repairable health and safety hazards can be replaced if warranted. Utility funds will pay for new system in some cases.

General Measures	Detailed Measures
• Water Heater Replacement	• Case-by-case analysis. • Non-repairable gas and electric water heaters can be replaced if warranted and funds allow. Utility funds will assist in payment in some cases. • Actively leaking water heaters can be replaced. • Any replacement should be with highest efficiency or energy factor available and practical.
• Combustion Appliance Measures	• Mandatory testing and documentation of tests in client file. • Eliminate hazards that pose imminent danger to health and safety of occupants.
• Mechanical Ventilation	• Ventilate in accordance with ASHRAE 62.2-2010 guidelines.
Repair Measures	
• Incidental Repairs	• If energy related materials are greater than $250 of DOE/DHHR funds, NEAT audit must be run to show cumulative SIR is greater than 1 (not to exceed $450).
• Replacement Doors and Windows	• Individual NEAT must be run to show measure SIR is greater than 1. Documentation to be part of client file. • Door and window replacement cannot be done in lieu of any mandatory measures. • Pre- and post-weatherization photo documentation must be included in client file.

Notes

- All mandatory measures are underlined.
- General measures are listed in order of priority based on SIR.
- Other measures (baseload, health and safety, repairs) are not listed in order of priority.
- All mandatory measures have SIRs greater than 4 and are expected to be done on all jobs. Thorough documentation must be provided if a mandatory measure is not performed.
- Recommended measures should be performed unless they are cost prohibitive. The reason for not performing the measure must be documented.
- Any variation from the priority list must be based on individual NEAT analysis.

3.9 Priority List for Mobile Homes

Auditor evaluations for mobile homes are similar in nature to site built structures. Different structural characteristics must be considered when evaluating for cost effectiveness. Different roof and belly configurations must be analyzed to assure the most appropriate installation techniques are prescribed.

Site evaluations should pay particular attention to documenting and evaluating existing insulation levels, attic cavity depths and construction types. Floor evaluations will also have the same considerations. Consistent insulation coverage without voids is important to note when evaluating measures crews direction on the Work Order.

The Mobile Home Priority List provides guidance to the auditor and crew supervisor for prescriptive measures that are based upon MHEA savings-to-investment ratio (SIR) justifications.

Mobile homes that fall outside normal parameters in manufactured housing will require a MHEA audit to evaluate cost effectiveness of measures. Audits are also required to prove the cost effectiveness of windows and doors, HVAC efficiency and refrigerator replacements. SIR justifications must be greater than 1.

Measures should be installed in the order listed unless specific documented health and safety measures take precedence.

General Measures	Detailed Measures
1. Heating System Clean and Tune	• Mandatory measure (unless system is being replaced.) Document all mandatory health and safety tests.
2. Air Sealing	• Mandatory measure. • Use blower door and zone pressure diagnostics to guide air sealing. • Ducts must be sealed as per duct diagnostic standards protocols. • Seal floors utilizing blower door guided diagnostics. • Home must be sealed at least to upper limit of the target range if cost effective.
3. Ceiling Insulation	• Natural Gas Heat – Mandatory measure if existing insulation is 2 inches or less with 6 inches or greater bowstring depth. • Electric, Oil or Propane Heat – Mandatory measure if existing insulation is 3.5 inches or less with 6 inches or greater bow string depth. • Mandatory measure on flat roofs with a cavity depth of at least 3 inches with no existing insulation, regardless of fuel type. If cavity depth is less than 3 inches and/or there is existing insulation, do not insulate.

General Measures	Detailed Measures
	• Mandatory on A frame construction (gable end blow) with 6 inches or less insulation, regardless of fuel type.
4. Floor Insulation	• Mandatory measure when there is 6 inches existing insulation or less or insulation with voids. • Mandatory measure for flat belly floors with 2 inches or less inches of existing insulation with no voids. • Existing floor measures must be based on consistent coverage (R-value and depth.) Inconsistent coverage (voids in belly insulation) requires the entire belly to be insulated.
• Heating System Replacement	• Case-by-case consideration. Replacement justification must be documented. • If replacing, must replace with 90+ high efficiency forced air unit or highest efficiency possible for direct vent space heater.
• **Baseload Measures**	
• DHW Insulation	• Mandatory measure on tanks with less than R-11 existing insulation (unless added insulation will void manufacturer's warranty.) Insulate tanks to a minimum of R-8 tank wrap.
• DHW Pipe Insulation	• Insulate the first 6 feet of cold and hot water pipe. • Insulate all water pipes that are outside the thermal boundary.
• Refrigerator Replacement	• Mandatory measure for DOE/DHHR if SIR is equal to or greater than 2. • Mandatory measure if paid by electric utility EEP and SIR greater than 1.5. • Optional measure if affordable for DOE/DHHR if SIR greater than 1.
• CFLs	• Mandatory measure if light is on more than 1 hour per day.
• Shower Heads	• Replace, with client permission, if existing flow is greater than 3 gallons per minute.
• **Health and Safety Measures**	
• Heating System Replacement	• Case-by case analysis. • Heating systems with non-repairable health and safety hazards can be

General Measures	Detailed Measures
	replaced if warranted. Utility funds will pay for new system in some cases.
• Water Heater Replacement	• Case-by case analysis. • Non-repairable gas and electric water heaters can be replaced if warranted and funds allow. Utility funds will assist in payment in some cases. • Actively leaking water heaters can be replaced. • Any replacement should be with highest efficiency or energy factor available and practical.
• Combustion Appliance Measures	• Mandatory testing and documentation in client file. • Eliminate hazards that pose imminent danger to health and safety of the occupants.
• Mechanical Ventilation	• Ventilate in accordance with ASHRAE 62.2-2010 guidelines.
• **Repair Measures**	
• Incidental Repairs	• If energy related materials are greater than $250 of DOE/DHHR funds, MHEA audit must be run to show cumulative SIR is greater than 1 (not to exceed $450.)
• Heating System Replacement	• Electric furnace can be replaced if beyond reasonable repair using electric utility EEP funds. • Combustion furnace replacements are allowable to replace if repairs are not feasible or repairs cost more than 2/3 the cost of a replacement. (Not subject to individual MHEA run when over $300.)
• Replacement Doors and Windows	• Jalousie windows can be replaced when not repairable and when there is significant air leakage discovered by blower door tests. • Door and window replacement cannot be done in lieu of any mandatory measures. • Pre- and post-weatherization photo documentation must be included in client file.

Notes

- All mandatory measures are underlined.
- General measures numbers 1 through 4 are listed in order of priority based on SIR.
- Other Measures (baseload, health and safety, repairs) are not listed in order of priority.

- All mandatory measures are expected to be done on all jobs. Thorough documentation must be provided if a mandatory measure is not performed.
- Recommended measures should be performed unless they are cost prohibitive. The reason for not performing the measure must be documented.
- All Mobile Home ceilings should be tested with a 4-inch observation port toward the center of mobile home to determine cavity depth and existing insulation levels.
- Gable-end blows are not permitted on bow string constructed mobile homes.
- Allowable measures or case-by-case measures are at the discretion of the agency and should be based on costs and professional opinion. They cannot supplant mandatory measures without and individual MHEA audit being run to justify them.
- Any variation form the priority list must be based on individual MHEA analysis.

4 Health and Safety Requirements

4.1 Introduction

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

With more advanced diagnostics and installation techniques utilized in the West Virginia Weatherization Assistance Program, it is increasingly necessary to take steps to insure that program measures do not cause or exacerbate health and safety problems for workers or clients. Repairs are limited to those related to energy efficiency and conservation, for example, alleviation of carbon monoxide being produced in a furnace as opposed to repairing porch steps.

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 are perceived to pose a threat to the crew or contractor's health and safety, the West Virginia's 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.
    f. In homes where radon may be present:
        i. Provide the client with EPA's consumer guide to radon.
        ii. Whenever conditions permit, exposed dirt must be covered with a vapor permeable ground cover.
        iii. In dwellings where radon may be present, precautions should be taken to reduce the likeliness of making radon concentrations higher.
        iv. Radon mitigation is not required by DOE.
        v. Radon testing is not an allowable DOE expense.
2. Air quality assessment, including:
    a. Interviewing client(s) regarding health conditions of occupants with the intent of determining if air quality is unacceptable.

b. Determination of ventilation needs for ensuring acceptable indoor air quality. Mechanical ventilation requirements will be based on *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*, ASHRAE Standard 62.2-2010.

3. Combustion systems assessment, including:
   a. Combustion safety testing, including worst-case depressurization spillage, breech draft, and carbon monoxide testing in appropriate dwellings before and after weatherization work. Additionally, it is required that worst-case depressurization testing be done while the work is being done, just before the crew or contractor leaves the job site for the day.
   b. Fuel storage and fuel distribution hazards, including oil tank or propane storage problems and oil, propane, and natural gas distribution line leaks.
   c. Hazardous combustion appliance conditions.
4. Assessment of 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 where lead testing has been completed and lead is found to be present, all weatherization work must be performed by weatherization personnel certified lead-safe work practices.

4.2 Expenditures

It is estimated that health and safety measures will account for an average of no more than 15 percent of the program operation's costs. This percentage may change and therefore the current allowable percentage for each program year is included in the agency's grant agreement. Since these measures are performed by agency direct-hire crews, and are usually installed simultaneously with energy efficiency materials, only material costs are directly tracked. The ratio percentage of health and safety materials to all materials is applied to personnel and program support to determine those costs. The primary goal of the Weatherization Assistance Program remains energy efficiency and conservation.

4.3 Reporting

Agencies report health and safety material costs on page two, Completed Dwelling Units, of the Monthly Progress Report. Total health and safety costs and percentages are tracked on the agency statistical tracking spreadsheet, maintained at both the state and local levels.

4.4 Agency Health and Safety

All agency related Health and Safety costs, such as personal safety equipment for the crews or combustion testing equipment, are charged to the Tools and Equipment line item of the Budget category of Program Support, which is part of Program Operations.

4.4.1 OSHA Requirements

Local agencies must comply with applicable Occupational Safety and Health Administration (OSHA) requirements.

4.4.2 Agency Safety Officer

1. A Safety Officer is to be designated at each agency. The safety officer coordinates the safety program and maintains all safety personnel records. Responsibilities of the safety officer include:
   a. Insuring all program field personnel have access to and demonstrate the proper use, maintenance, and storage of all tools, equipment, and safety equipment;
   b. Conducting scheduled safety meetings, documenting subject matter, keeping attendance records, and maintaining all required forms; and
   c. Enforcing all safety regulations to insure worker safety. Personnel who are not following safety practices or not properly using safety equipment must be removed from the job site until training or correction of the violation can be provided. A report must be included in the worker's safety file.

4.4.3 Safety Meetings

Safety meetings must be held at a minimum of every other month. The safety officer should determine the content of the meetings based on issues of current importance. It is recommended to limit each meeting to one topic, such as ladder safety or Material Safety Data Sheets, to help the worker retain and understand the information covered. Content of meetings and attendance must be documented. It is recommended to give brief post tests on the addressed safety issue so employees can demonstrate their knowledge and understanding of the topic.

4.4.4 Respirator Fit Tests

Each Weatherization Assistance Program field employee is required to have a respirator fitted in accordance with a qualitative respirator fit test using an approved vapor gas test agent, as described by the manufacturer of the fit test kit and OSHA/NIOSH regulations. Qualitative fit tests will be given to each employee every 12 months. The test should be documented on the Qualitative Respirator Fit Test form. This form will be monitored by State annually.

4.4.5 Spirometry Tests

It is required that all field workers have a spirometry test at least every 18 months performed by a physician or respiratory therapist to determine the worker's physical ability to wear a respirator and perform tasks while wearing it.

4.4.6 MSDS Station

A copy of a product's Material Safety Data Sheet (MSDS) will be maintained in each warehouse at a designated "Right to Know Station." MSDS books should also be maintained in each program vehicle. Each employee must have access to the information in the MSDS books.

4.4.7 Emergency Eyewash Stations

Where the eyes or body of any person may be exposed to injurious corrosive materials, suitable facilities for quick drenching or flushing of the eyes and body will be provided within the work area for immediate emergency use.

4.4.8 Emergency Phone Numbers and Employee Information Sheet

The warehouse and each program vehicle must contain at all times a list of emergency phone numbers, and a list of all employees with their emergency contact information. The Health

Insurance Portability and Accountability Act of 1996 (HIPAA), will not allow employers to keep medical information such as employee's allergies or medications.[1]

4.4.9 Personal Protective Equipment

1. Head Protection
   a. Hard hats or bump caps are required to protect the worker from accidental head injury.
2. Respirators
   a. Respirators are necessary when blowing cellulose or fiberglass insulation and when installing fiberglass batt insulation. Dust from insulation is likely the most serious potential health hazard facing crew workers, and using the correct respirator is mandated whenever handling or installing insulation.
   b. Each field employee will be provided with a fitted respirator. The employee will receive training on how to select, maintain, clean, and store their respirator. They are responsible for its routine maintenance. Any problems or malfunctions must be reported to the safety officer.
   c. When installing any type of insulation, a full-face respirator is required. Filters should meet specifications N 7500-8, approved by National Institute of Occupational Safety and Health (NIOSH) and Mine Safety and Health Administration (MSHA).
   d. Disposable dust mask respirators can also be used when full-face respirators cannot be worn. Use a NIOSH/MSHA approved respirator, such as a 3M model #8710 or #9900 or equivalent. Proper fitting is a necessity.
3. Eye Protection
   a. Goggles, plastic shields or safety glasses with side shields, are to be worn whenever there is a chance of particles flying into the eyes. Use the proper eye protection whenever drilling, blowing insulation, cutting glass or Plexiglas, working with fiberglass and sawing. Glasses and sunglasses are not approved eye protection.
4. Gloves
   a. Each worker should have good quality work gloves to protect the hands while handling glass, fiberglass, aluminum, wood, and cellulose. Gloves with cuffs are recommended since they also protect the wrist.
5. Shoes
   a. Good quality work boots are recommended. Good quality means boots (or shoes) with a heavy, treaded sole that offers support, traction and protection. The uppers should be made of leather to protect the ankles and lower leg from scrapes and punctures. Tennis or other athletic shoes do not give proper protection.
6. Clothing
   a. Work clothes should be worn instead of old dress clothes. Long sleeved shirts offer better protection than T-shirts. Long pants offer more protection than short pants or dresses/skirts. Layers of clothing are recommended so that the worker

[1] The Health Insurance Portability and Accountability Act of 1996 (HIPAA), Public Law 104-191, was enacted on August 21, 1996. To view the entire Rule, and for other additional helpful information about how it applies, see the Office for Civil rights website: http://www.hhs.gov/ocr/hipaa.

can adjust to the temperature. Loose clothing helps prevent insulation fibers or dust from rubbing against the skin.

b. While working in winter temperatures, several layers of lighter clothing will keep a worker warmer and afford easier movement than heavy and bulky clothes.

7. Personal Protection Rules
   a. Confine long hair so that it is not exposed to machinery and does not interfere with vision.
   b. Require the wearing of safety goggles, safety glasses or other eye protection when there is danger of eye injury.
   c. Enforce the use of respirators where harmful dusts or fumes exist.
   d. Require workers to remove rings and other jewelry while working on-the-job or in the shop area.
   e. Where noise levels are excessive over long periods of time, ear protection must be worn.
   f. Protective apparel must be worn as required by the nature of the task.
   g. Dresses/skirts must not be worn on the job site.
   h. Determine the physical defects and limitations of all those on the job so that they will not be assigned tasks detrimental to their health or physical condition.
   i. Prohibit the wearing of clothing that could be loose enough that it could get caught on protruding objects or caught in machinery or power tools.

4.4.10 Crew Safety Equipment

1. The following is a list of mandated safety equipment that each crew must have on the job in accordance with the tasks scheduled to be performed.
   a. Water jug.
   b. Exhaust fan for the attic.
   c. Ladder levelers.
   d. Ladder stabilizers.
   e. Ground Fault Circuit Interrupters (GFCI).
   f. Proper type and gauge extension cords for the task, but at least 12 gauge with ground (12-3).
   g. Double insulated power tools.
   h. Trouble light, three-wire including ground.
   i. Bee spray.
   j. Industrial size first aid kit.
   k. Fire extinguisher.
   l. Flares or warning lights.
   m. Flashlight.
   n. Ground-cable for generator.
2. Body Mechanics
   a. Use as many muscles as possible to distribute the work load.
   b. Both hands are used to pick up heavier objects.
   c. Lifting heavy objects alone is to be avoided. Help should be requested.
   d. Pushing is preferred to pulling.

e. Leg muscles are used to lift heavy objects rather than back muscles.
f. Bending and unnecessary twisting of the body for any length of time is to be avoided.
g. Work is done at the proper level.
h. Long pieces of material are carried by two people.

3. Ground Fault Circuit Interrupters (GFCI)
   a. Whenever power tools or electrical equipment are used, it is mandated that a GFCI be used.
   b. Since GFCIs merely sense differences in current flow between one side of a circuit and another; they protect people, not wires. If a short circuit should develop, the GFCI will probably open, but it may not before the fuse blows or the breaker trips. The practical message then is: 1) avoid hazardous situations that could cause short circuits and 2) bring along extra fuses and breakers just in case.
   c. GFCIs cannot protect you from all possible kinds of shock. If you cut through the extension cord feeding the GFCI you will get shocked. Or, if you cut through another wire in the attic not connected to a GFCI, you will get shocked. A GFCI only protects you from shock that could occur between you and the GFCI.
   d. Sometimes the GFCI opens the circuit for no apparent reason. These are called "nuisance faults." Though the GFCI can be reset quickly, such faults are indeed a nuisance. When the GFCI opens the circuit, however, it may be telling you something important! A tool may have an intermittent ground fault. This can be the most dangerous kind of electrical problem of all, for it may occur when you least expect it. If a GFCI continually needs resetting for all tools, check the GFCI. If a particular tool frequently causes the GFCI to open, check the tool.
   e. Read the directions on the GFCI you purchase and brief your crews carefully before sending them out. Portable units are sturdy, but like all good equipment, they should be treated with care and kept away from dirt and moisture. Each unit should be tested frequently.
   f. Each truck must stock a minimum of one GFCI.

4. Electrical Safety
   a. All of the following practices and procedures are generally accepted safety practices and should be observed at all times.
      i. Equipment will be properly grounded.
      ii. All switch boxes, junction boxes, wires, and conduits must be properly covered or closed.
      iii. Wire and cords that are defective, inadequate, worn, frayed, wet, oily, or have deteriorated insulation, must be removed from service and replaced immediately.
      iv. Defective switches, receptacles, extension cords, lamp sockets, tools, or equipment must be repaired immediately or properly marked and made inoperable.
      v. All stationary and portable electrical tools must be properly connected and grounded according to manufacturer's specifications (except double insulated tools).
      vi. Ground Fault Circuit Interrupters (GFCI) must be used.

vii. Broken housing and loose or vibrating machine parts must be replaced before equipment is used.
viii. Electrical panels, switch boxes, motors and other electrical equipment must never be cleaned with water or dangerous solvents.
ix. Never overload circuits or overuse circuits by using the wrong size or type of fuse.
x. All equipment or circuits being worked on or repaired must be locked out or otherwise de-energized and tagged.
xi. All installation or extension of electrical facilities must comply with the current National Electrical Code.
xii. Heavy duty, grounded extension cords designed for industrial services only must be used.
xiii. Extension cords must never be used to operate stationary equipment or other permanent operations.
xiv. Clearance of 30 inches and clear access must be maintained around all electrical panels.
xv. Work practices which overload motors, insulation, wires, or electrical accessories must be avoided.
xvi. Electrical cords must be disconnected by pulling on the plug, not the cord.
xvii. All switch panels, circuits, outlets and boxes at the warehouse and office must be utilized for all electrical installations.

5. Generator Safety
   a. Generators rather than the client's home electrical supply should be used on the job site.
   b. Generators should be grounded with a ground rod driven into the ground.
   c. Generators must not be used in any enclosed area, including the back of the weatherization truck.
   d. Exhaust from the generator must always be released to the outdoors, away from the truck and away from the home.

4.4.11 Hot Weather Precautions

1. If proper precautions are taken, the vast majority of heat problems can be avoided. When working in high temperatures, drink large quantities of cool water (10-15 glasses a day). Eat light, easily digestible foods.
   a. Whenever possible, take turns when blowing insulation in the attic. Do not spend more than 15 to 20 minutes at a time in the attic. If dizziness occurs, get out of the attic immediately.
   b. Plenty of cool water and salt tablets (for those permitted to take them—be sure you know if any worker has high blood pressure) are the best prevention against heat related health issues.
   c. Attic work should be started and finished early. Predetermine the temperature at which the work in the attic will stop.
   d. Be sure that work in an unvented attic does not begin until the vent openings are cut. It is mandated that each crew have an electric fan to aid in the venting of the attic.
   e. Familiarize yourself and fellow workers with the symptoms of heat stroke, heat exhaustion, and heat cramps (discussed below).

f. Mandated protective equipment such as hard hats, goggles, respirators, and long sleeve shirts, although uncomfortable, must be worn while insulating work is being done to prevent short-term and possible long-term problems to the eyes, skin and lungs. When insulating in hot weather, limit time in the attic and drink plenty of water.

2. Heat stroke is a life threatening condition. Someone suffering from heat stroke becomes dizzy and then quickly loses consciousness. They may have a severe headache before they lose consciousness. Their face will be red and the skin will be hot and dry. There will be no perspiration. The pulse will be strong and rapid and breathing will be labored and the pupils of the eyes will be dilated.
   a. Get medical help at once!
   b. Treatment: lower the body temperature as soon as possible. Get the person to a cool place and elevate their head to reduce the flow of blood to the brain.
   c. Remove most of the person's clothing and cool the body using a wet sheet, water, or whatever is on hand. Rub the body and head with ice if it is available.
   d. Continue the treatment until consciousness returns or the temperature returns to normal. Watch for signs of shock and treat accordingly.
   e. Give the patient all the cool water he wants, but no stimulants.
   f. If the person becomes hot and dry again, renew the cold application.
3. Heat Exhaustion: Heat exhaustion is a state of collapse from the effects of heat. It happens more often when the humidity is high. The person feels very weak and will probably vomit. They may feel chilly. The pulse is rapid and weak, and breathing is shallow.
   a. Get medical help at once!
   b. The treatment is the same as for shock. Place the person with their head lower than the rest of their body. The mouth should be cleaned and the body covered. Apply cold compresses.
   c. Give salt in the form of a tablet or a pinch of salt in a glass of water. If the person vomits, do not give any more fluids.
   d. A person that has suffered from heat exhaustion should not work for a few days.
4. Heat Cramps: Heat cramps are painful muscle spasms that happen most often in the abdomen, arms, and legs. Heat cramps occur while doing hard work in high temperatures without taking any precautions. They may be slight or convulsive and may last a few minutes to 24 hours. After being relieved, the spasms may be renewed by exposure to a cold draft or exertion. Loss of salt from muscle tissue is the main cause of heat cramps.

4.4.12 Cold Weather Safety Precautions

1. The following are recommended cold weather practices and precautions.
   a. Agency personnel should pay particular attention to weather forecasts in the winter season. This enables work to be scheduled according to changes in the weather and to alter clothing accordingly.
   b. Proper clothing is extremely important in the winter. Crew members should be supplied hard hat liners and two sets of warm winter gloves. They should also be encouraged to use insulated boots with a non-slip tread.

c. For warmth, several layers of light clothing are recommended instead of thick bulky clothing, to allow for freer movement. A pair of insulated coveralls is a good idea.
d. All crew members should be made aware that strenuous work for long periods of time is dangerous because the body does not think it is as tired as it really is. Work should be done in short intervals to prevent exposure and overtiring.
e. Trips in and out of the house should be kept to a minimum to prevent cooling of the dwelling unit, exposing the client to the cold, and tracking snow and mud into the dwelling.
f. Power tools should be used with extreme caution due to the possibility of electrical shock caused by wet feet, wet ground, and bad footing.
g. Blower machines should be protected from the weather by elevating them on blocks, placing them on dry plywood or lumber, or placing them in a dry covered area (porch, step van, garage, etc.).
h. All tools and equipment with motors should be warmed up prior to use.
i. Care should be taken in the placement of extension and power cords.
j. Exercise extreme caution and sound judgment concerning ladder work on extremely windy days.
k. Ladders should be dug into the ground to provide a non-slip footing.
l. Taking frequent breaks and drinking plenty of warm liquids will keep crew members warm and help prevent health issues.
m. Be especially aware of the symptoms of frostbite and hypothermia.

4.4.13 Fire Safety – Office, Warehouse, and Vehicles

1. The following safety practices are critical to prevent the risk of fire in the office, warehouse, and vehicles.
   a. Provide and properly mount approved fire extinguishers in vehicles, warehouses and offices. Multi-purpose dry chemical units are most effective for general use. Multi-purpose dry chemicals can damage delicate electrical equipment. Gas type extinguishers eliminate that problem. Halon 1211 is more effective and less costly than CO_2 for extinguishing electrical fires.
   b. Inspect and test fire extinguishers at regular intervals to ascertain that they are fully charged and in proper working condition.
   c. Agency must provide fire extinguisher training annually for all weatherization personnel.
   d. When storing flammable liquids, observe the following:
      i. Limit supply to small amounts. Keep flammable liquids on hand only if absolutely necessary.
      ii. Store flammables properly in airtight metal cans and in well ventilated areas. Make sure all containers are labeled.
      iii. Dispose of them safely in metal containers with tight lids. Discard them as soon as possible.
      iv. Clean up spills or leaks promptly.
   e. Never smoke around flammable liquids. Even a tiny spark or ash can cause a fire or explosion.
   f. Provide instruction to agency personnel in the location and the proper use of fire extinguishers and other firefighting equipment.

g. Segregate oxidizers and oily materials in storage.
h. Provide Underwriters Laboratories Listed or oily waste containers for oily and paint soaked rags. It is a good policy to place waste with spontaneous combustion potential in water filled containers.
i. Post fire alarm and evacuation procedures.
j. When possible, prohibit use of flammable liquids for cleaning purposes.
k. Provide for bulk storage of flammable materials in an area removed from agency facilities.
l. Agency personnel should be aware of the location of emergency shutoff valves and switches in the event of a fire.
m. Do not stack materials within 30 inches of sprinkler heads.

4.4.14 Power Tool Safety

1. Be aware that improper handling and operation of power tools can cause very serious injuries and possibly death. See also the Electrical Safety and Equipment Safety subsection.
   a. Always use a properly grounded Ground Fault Circuit Interrupter.
   b. Remove jewelry, eliminate loose clothing, and confine long hair.
   c. Be sure there is enough light to do the job safely.
   d. Keep all safety guards in position and wear protective equipment. Eye protection is always in order.
   e. Be sure to use grounded plugs or double insulated power tools.
   f. When cords become damaged, they must be replaced.
   g. Never operate power tools with an unclear head.
   h. Never operate power tools unless you are thoroughly familiar with the controls and operations. When in doubt, consult someone who is familiar with them.
   i. All power tools should be carefully inspected regularly. Look for frayed or bare wires, dirt and dust in the tool, and a tight connection of the cord.
   j. Make sure that the blade or bit is tightly clamped to the chuck.
   k. Make sure that the power switch on the tool is off before connecting it to the power sources.
   l. While operating a power tool, give it your undivided attention.
   m. Keep cutting pressure constant and do not force the blade or bit into the material.
   n. Do not operate power tools with dull blades and bits. This can result in serious injury or lessen the life of the power tool.
   o. Do not distract or in any other way disturb a person using a power tool.
   p. Never try to clear jammed power tools until you disconnect the power source.
   q. After using a power tool, turn the power off and remove the plug from the power source. After tool movement has stopped, clean the tool before putting it away.
   r. When using an extension cord, always plug the tool into the extension cord before the extension cord is connected to the power source. Break the connection between the extension cord and the power source before disconnecting the tool from the extension cord. The tool cord and extension cord should generally not be longer than 25 feet each to guard against overheating.

s. Be sure that power cords do not come in contact with sharp objects.
t. Tool cords and extension cords should be long enough so that they do not need to be pulled tight.
u. Cords should be checked often to detect overheating. If a cord is uncomfortably warm, then something is not right and warrants inspection by a qualified person.
v. Make sure that cords are lying so that they do not interfere with other workers.
w. Electricity must be regarded with respect and handled properly. If there is water in the area extreme caution must be observed. Water will greatly increase the chance of grounding and shock.
x. Workers must always report any shock received from electrical equipment no matter how minor the shock might be. Minor shocks can lead to fatal shocks.

4.4.15 Hand Tool Safety

1. Hand tools are sometimes taken for granted but are used more often than other tools and equipment. The following are safety practices concerning the use of hand tools on the job.
   a. Establish regular tool inspection procedures to ensure that hand tools are maintained in a safe condition. Dull blades, broken screwdriver blades, cracked handles or loose heads can cause injuries.
   b. Use good quality tools instead of cheap ones.
   c. Keep hand tools in a safe place. Tools left lying around can get stepped on and broken or become a tripping hazard.
   d. Do not lay a tool near power tools in use.
   e. Do not put sharp objects or tools in pockets of clothes. This could result in being stabbed or cut.
   f. Use the proper tool for the job.

4.4.16 Ladder Safety

1. The following safety practices for using ladders are particularly critical due to the potential of serious injury when working with ladders.
   a. Ladder levelers and stabilizers are to be used on all straight and extension ladders.
   b. In accordance with OSHA requirements ladders must be inspected prior to each use in order to find bends and cracks that could weaken the ladder.
   c. Regularly check the shoes at the bottom of the ladder to see that they are intact and secure.
   d. Ladders must not be placed on boxes, barrels, or other unsuitable bases to obtain additional height.
   e. Ladders are to be stored horizontally on the floor or on supports to prevent sagging.
   f. The rungs are to be kept in a non-slippery condition.
   g. Follow the Rule of Ten: Keep ladders at least ten feet from power lines running into the house.
   h. Brace the ladder when you are raising it. Walk forward under the ladder, grasping each rung until it is upright. Use part of the house or have another person brace the ladder. Make sure the ladder will clear wires and trees.

i. Special precautions should be taken when erecting and climbing a ladder on a windy day.
j. Set the base of the ladder out one foot from the house for every four feet up.
k. No ladder should be used to gain access to a roof or any other elevated position unless the top of the ladder will extend at least three feet above the point of support.
l. Make sure the parts of the extension ladders overlap enough.
m. Have another worker hold the ladder if the ladder is extended over half of its closed length or there is a question as to its stability.
n. Be sure that your shoes are not greasy, muddy or slippery before climbing.
o. Always face the ladder when climbing up or climbing down.
p. Keep your belt buckle between the ladder rails. Do not overreach. Moving the ladder is more sensible than a possible serious injury.
q. If materials are to be carried up and down a ladder, carry them with the front end elevated.
r. Carry tools in a tool belt. Use both hands for climbing up and down.
s. Do not climb higher than the third rung from the top on straight or extension ladders.
t. Do not climb higher than the second tread from the top on stepladders.
u. Block and guard ladders when they must be placed in driveways or on walkways.
v. Never drop a ladder; the stress can weaken the ladder.

4.4.17 Pests in the Attic and Crawl space

1. If you encounter bees, wasps, and other flying insects:
   a. Find out if anyone in your program is allergic to bee stings. If so, have them obtain an anti-venom kit from a local drug store and instruct them to have it with them at all times while on the job.
   b. If a person on your crew is allergic to bee stings, it is important that this person is alerted if an unseen nest is disturbed so that they can move to a safe distance from the swarm.
   c. It is possible that a person may not know that they are allergic to bee stings. The symptoms of an allergic reaction are faintness, nausea, and/or shortness of breath. If a person is experiencing these symptoms, GET MEDICAL HELP AT ONCE.
   d. If a dwelling is known to have a bee problem, plan ahead of time to exterminate the bees. This will allow the attic or crawl space to air out and prevent unnecessary inhalation of the insecticides used. Late in the evening or early in the morning while the bees are in their nest is the best time to exterminate.
   e. For nests in the ground, pour oil, gasoline, or kerosene in and around the nest. Important: Do not ignite the fuel—the fumes are enough to kill the bees.
2. Rats and Mice
   a. Rats and mice are usually found where you find food scraps at open garbage bins.
   b. The client or landlord should be told to remove any harborage within 100 feet of the dwelling unit.

c. The droppings are of major concern since contact with them can create infectious diseases. Soap will not cleanse harmful bacteria from the skin. A disinfectant towelette should be used.

d. If a rat or mouse bites someone, medical attention should be sought immediately.

e. If the infestation is particularly serious, notify the local Health Department.

3. Bats

a. To remove bats from a dwelling, first tightly close any large openings and then caulk, pack, or cover with galvanized mesh all but the opening they use most; then wait until all the bats have left the attic and close the hole.

b. Dried droppings are the major source of contamination from bats. When working around the droppings an aseptic mask should be worn and skin contact with droppings should be avoided by wearing rubber gloves. Wearing goggles can prevent contact through the eyes. If bats are present, gloves and heavy clothes should be worn to prevent possible bites.

c. Bat bites are rare; however, if a crew member is bitten, a physician should treat them. An effort should also be made to obtain the particular bat.

d. If the infestation is particularly serious, notify the local health department.

4. Snakes

a. To eliminate snakes, eliminate harborage such as lumber piles, rock piles, and debris under porches and house.

b. When working where the presence of snakes is a possibility, wear protective leg and foot covering and heavy gloves.

e. If a poisonous snake bites a person they should be transported to a medical facility at once, particularly if that person was bitten by a rattlesnake. First aid should be administered immediately.

f. Poison control hotline telephone number is 800-222-1222.

4.4.18 Safety in the Attic

1. The following considerations should be noted on the Residential Audit Form/Work Order so that a worker can be aware of what he will be dealing with when preparing to do attic work.

a. Is there a chimney or flue? If so, does it need a collar or dam?

b. Are there exposed wires? If so, the client should be informed to have them replaced before insulating work can be done.

c. Are there open electrical junction boxes? These will have to be covered with junction box covers.

d. Are the ceiling joists strong enough to support a worker's weight?

e. Are there recessed light fixtures? Never insulate over a recessed light fixture unless it is labeled "Type IC" (these double-housed fixtures are rated to be in contact with insulation).

f. What type of pests might be encountered in the attic? Bees are usually encountered in an attic especially in the summer months. All programs should have an adequate supply of bee spray. Bats may be encountered and this constitutes a health problem. A person can still be infected by rabies from

contaminated air. If bats are present the local Health Department should be contacted.

g. Be aware of children and large animals such as dogs. You must remember that you are liable for the client's family safety as well as your own. Children may be injured by tools or by climbing on ladders. Advise the client to keep children out of the work area. If animals become a problem have the client remove them accordingly.

2. The following equipment should be used when working in the attic:
   a. Hard Hat.
   b. Goggles.
   c. Respirator.
   d. Gloves.
   e. Long pants.
   f. Lighting.
   g. Walking board(s).
   h. Fan(s) for ventilation.
3. Other attic precautions:
   a. Be aware of what you are doing at all time. Be aware of what is above you, behind you, to the sides of you, and below you.
   b. Be sure there is sufficient lighting and ventilation for the job you are doing.
   c. Be especially cautious in hot weather.
   d. Be aware of electrical service wires at all times.

4.5 Client Health and Safety

The primary health and safety problems encountered by clients are related to combustion appliances, poor indoor air quality resulting from excess moisture, and electrical hazards that lead to injury and fire.

4.5.1 Health Concerns for the Occupants

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 (when available) during the audit "walk-through." This can be particularly effective as the auditor notices and discusses potential hazards.
3. Dwellings with unvented (vent-free) combustion appliances used as a primary heat source, with the exception of gas ranges, may not be weatherized until such appliances are properly vented to the outdoors (according to the appropriate code) or removed. Refer to Section 10.3.4 on page 105 for more information.
4. Building owners and clients must be notified of any health or safety problems that require terminating the weatherization work. Documentation of this notification must be included in the client file.
5. It is preferred that agencies minimize or restrict the use of materials that may be hazardous to the client; however, if the agency must use 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.

7. Agencies should try to protect all clients from respirable particles, such as paint or insulation dust, during the weatherization process.
8. The installation of hazardous materials must be done in well-ventilated areas.
9. Weatherization personnel will not smoke cigarettes, cigars, or pipes in a client's home or outdoors within 25 feet of the client's home. Smoking must be done in a designated smoking area with a container to dispose of butts.
10. If strong smelling chemicals, such as formaldehyde, are detected in the client's home, agencies should not perform any weatherization measures that would reduce the natural air leakage of the dwelling, unless mechanical ventilation is present or installed.
11. 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. Raw sewage leaking from waste plumbing pipes.
    c. Mold and moisture.
    d. Friable asbestos. Please refer to Section 4.13 on page 40 for more details.
        i. Asbestos pipes.
            1. In the West Virginia Weatherization Assistance Program, asbestos on pipes is relatively rare because there are few boiler systems in the program housing stock. Dealing with asbestos pipes is beyond the responsibilities of program crews, and they are instructed to avoid contact with the pipes. If the condition of the asbestos is deteriorated enough to pose an immediate safety problem in the area, the agency can defer services until the problem is rectified.
        ii. Asbestos siding.
            1. When house siding is suspected of containing asbestos, crews will not drill through the siding. In this case, the crew will attempt to blow the sidewalls from the inside.
    e. Radon gas.
        i. There are few instances of previously identified radon problems in the housing stock of the West Virginia Weatherization Assistance Program. Program crews do not test for radon. Common practices such as installing 6-mil plastic ground vapor barriers and installing crawl space venting may help mitigate any existing radon problems.
    f. For lead safe weatherization requirements, please see Section 4.14 on page 40.
12. Duct Cleaning and Sealing.
    a. All supply and return ducts must be sealed for energy efficiency and to prevent foreign particulates from entering and being blown into the conditioned space. Leaky ductwork can also create positive or negative pressures (depending on location of leaks in supply and return ducts) that can have an effect on the draft of combustion appliances. Refer to Section 6.11 on page 66 for details.
    b. During weatherization work, ducts should be kept as clean as possible. Crews should clean the ducts around registers and replace furnace filters.

4.5.2 Injury Prevention for Occupants

1. Minor repairs may be done when weatherizing a home in order to prevent injury to weatherization workers during weatherization and to occupants. These repairs may only be done to the extent of ensuring safety. These minor repairs might include:
   a. Replacing missing light bulbs.
   b. Lowering domestic hot water temperature.

4.5.3 Preexisting Occupant Health Condition

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

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

4.6 Combustion Appliances and Heating Systems

1. Repair and replacement of inoperable or unsafe combustion appliances is allowed, including the installation of direct-vent, sealed-combustion appliances.
   a. Repair and cleaning should be considered before replacement.
   b. Proper venting to the outdoors, including gas dryers and range hoods, is required.
      i. Correction of venting is allowed when testing indicates a problem.
2. System repair, replacement, or installation is allowed of red-tagged, inoperable, or nonexistent heating systems where climate conditions warrant.

4.6.1 Water Heaters and Other Appliances

1. Poorly functioning water heaters that may pose a health concern may be replaced on a case-by-case basis.
   a. Installation of one per dwelling is allowed.
   b. Documentation must be maintained to justify replacement.
   c. Replacement and installation of other appliances for health and safety reasons is not allowed. Repair and cleaning are allowed.

4.7 Formaldehyde and Volatile Organic Compounds (VOCs).

Crew awareness of potential problems with formaldehyde and volatile organic compounds is important when addressing air sealing. Crews are instructed to remove any VOCs when possible and to give client education regarding the potential dangers. Crew supervisors are given the flexibility to raise air tightness limits if warranted. If air tightness standards are increased, the reason for the increase must be included in the client file.

4.8 Biologicals

The detection and remediation of mold, odors, viruses, bacteria, unsanitary conditions, and rotting wood is often beyond the scope of the Weatherization Assistance Program, and may be a reason for delaying work. Since workers often encounter these conditions, they try to remedy the situation if possible and take precaution to not exacerbate any potential problem. Factors such as cleaning agents, paints and turpentine, gasoline, sewage, animal waste, and excessive dust can sometimes be addressed to allow weatherization work to occur.

4.9 Stand-Alone Electric Space Heaters

Repair, replacement, or installation of stand-alone electric space heaters is not allowed.

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

4.10 Spray Polyurethane Foam Use

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

1. When working within the thermal enclosure with spray urethane foam, follow the EPA guidelines[2] or manufacturer's guidelines.
2. When using spray urethane foam outdoors, isolate the area where the foam will be applied, take precautions to ensure the fumes will not be transferred to the indoor living area.
3. Make sure all State and local fire codes are followed when spray polyurethane foam is used indoors.

4.11 Unsanitary Conditions

Unsanitary conditions, including raw sewage, are sometimes encountered. Traditionally, crews have done their best under the circumstances to proceed with weatherization work. If the conditions would endanger either the crew or client if work were performed, the job may be deferred until such conditions can be corrected.

4.12 Miscellaneous Health and Safety Rules

1. Replacement, repair or installation of windows or doors is not an allowable health and safety cost, but may be allowed as an efficiency measure if justified by the NEAT or MHEA audit.
2. Replacement, repair, or installation of telephones is not an allowable cost.
    a. Provide client information about telephone replacement programs.

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

3. Vented space heaters should be treated as normal heating systems and should be tested in a manner similar to central furnaces.
4. Repair and replacement of solid-fuel heating appliances is allowed only when client health and safety are a concern and there are compliance issues with NFPA 211. Refer to Section 10.3.5 on page 106 for more information.

4.13 Asbestos Inspection Procedures

1. Because there is the possibility that the weatherization testing or work may disturb materials that may contain asbestos, the energy auditor must inspect for such materials prior to beginning work.
2. Decisions on approaches to weatherization work where asbestos is present will be based on the judgment of the most qualified individual available to the agency.
3. When major energy-saving measures might be sacrificed as a result of suspected asbestos-containing materials, the agency should have the suspected material tested for asbestos content.
4. All agency workers must wear high-quality respirators any time they work with asbestos.
5. When working with materials containing asbestos, the materials should be dampened with water whenever possible to reduce the risk of airborne asbestos fibers.
6. Joint compound used on drywall might contain asbestos fibers.
7. Materials containing asbestos may not be cut, drilled, or disturbed in any manner that may cause asbestos fibers to become airborne.
8. Removal of asbestos siding is allowed when performing energy-saving measures. All precautions must be taken not to damage the siding. The siding should never be cut or drilled. It is recommended, where possible, to insulate through the interior walls.
9. On covering materials, such as steam pipe insulation, assume asbestos is present. Abatement—either removal or encapsulation—is allowed by a certified asbestos abatement contractor.
10. When vermiculite insulation is found in an attic, unless testing proves otherwise, take precautionary measures as if the vermiculite contains asbestos. Encapsulation by an appropriately trained asbestos control professional is allowed. Removal is not allowed. Blower door testing should be done with pressurization rather than depressurization.

4.14 Lead Safe Weatherization (LSW)

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

Lead-Safe Weatherization (LSW) includes weatherization worker protection, general LSW work practice standards, and lead dust containment standards. Please refer to the latest weatherization program standard for details.

1. Level 1 Containment.

a. Level 1 containment is required in pre-1978 homes when less than 6 ft^2 of interior painted surface per room or 20 ft^2 of exterior painted surface will be disturbed.
b. Level 1 containment consists of methods that prevent dust generation and contains all debris generated during the work process. The containment establishes the work area which must be kept secure.
c. Measures that may fall within this guideline include:
    i. Installing or replacing a thermostat.
    ii. Drilling and patching test holes.
    iii. Replacing HEPA filters and cleaning HEPA vacuums.
    iv. Changing furnace filter.
    v. Removing caulk or window putty (interior).
    vi. Removing caulk or window putty (exterior).
    vii. Removing weatherstripping.

2. Level 2 Containment.
    a. Level 2 containment is required when Weatherization activities will disturb more than 6 ft^2 of interior surface per room or 20 ft^2 of exterior surfaces in homes built prior to 1978. Level 2 containment consists of methods that define a work area that will not allow any dust or debris from work area to spread. Level 2 containment requires the covering of all horizontal surfaces, constructing barrier walls, sealing doorways, covering HVAC registers with approved materials, and closing windows to prevent the spread of dust and debris.
    b. Measures requiring level 2 containment may include:
        i. Drilling holes in interior walls.
        ii. Drilling holes in exterior walls, removing painted siding.
        iii. Cutting attic access into ceiling or knee walls.
        iv. Planing a door in place.
        v. Replacing door jambs and thresholds.
        vi. Replacing windows or doors.
        vii. Furnace replacements.
    c. Additionally, Level 2 containment must ALWAYS be used where any of the following is conducted (even if the activities will disturb less than the hazard levels within the Level 1 category):
        i. Window replacement.
        ii. Demolition of painted surface areas.
        iii. Using any of the following: Open-flame burning or torching; machines to remove paint through high-speed operation without HEPA exhaust control; or operating a heat gun at temperatures at or above 1100 F^O. Note that the use of a drill, reciprocating saw, or other power tool is considered a "machine" for removing paint. As examples: Cutting an attic hatch inside the dwelling or interior drilling of holes for the installation of insulation require level two containment.

3. There must be adequate documentation in the client file to demonstrate that lead safe weatherization measures were performed when necessary. Documentation should include photos of the site and containment set up, as well as a listing of materials used and measures taken. Quality control inspector must also certify that LSW procedures were used and properly implemented.

4. West Virginia Weatherization will adhere to EPA lead safe rules as written in the "Lead; Renovation, Repair, and Painting Program" Final Rule (LRRPP Final Rule), as directed by DOE.
5. Weatherization of HUD program housing stock, including HUD Section 8, is infrequent in West Virginia. These units will only be weatherized if the owner provides a Certificate of Lead-Based Paint Compliance (copy must be in client file) that documents abatement or control of any lead paint hazard has been addressed, and will agree that the local agency will not be liable for any lead hazards, provided the safe work practices generally outlined above are employed.
6. In cases where the agency cannot safely weatherize a home due to lead paint hazards, the agency may defer the work. Such deferral will be considered by the state on a case-by-case basis. Agencies may not weatherize dwellings where there are cases of documented or suspected lead poisoning. Additionally, they will not weatherize homes where there is an extraordinary lead paint hazard with no means to abate the hazard, including insufficient funds or insufficient training to properly address the hazard.

4.15 Moisture Remediation, Assessment, and Repair

4.15.1 Remediation of Mold and Mildew Problems

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. Other funding sources should be sought to cover the cost of eliminating mold that is beyond the scope of the weatherization program.

All homes will be inspected for previous and existing moisture problems using the Mold Procedure/Checklist Form to document existing mold and moisture related problems in homes.

In West Virginia, excessive moisture is often a problem. Common measures for dealing with potential moisture problems include:

1. Repair or installation of bathroom and kitchen exhaust fans;
2. Installation of ground moisture barriers of six mil black plastic under enclosed foundation mobile homes, houses receiving sidewall insulation, or any house with excessive dampness in the crawl space;
3. Repair or installation of dryer vents to be properly vented to beyond the perimeter of the crawl space or basement;
4. Installation of attic venting and crawl space venting, but only when appropriate;
5. Installation of exhaust fans as per ASHRAE 62.2-2010; and
6. Replacement of downspouts and/or gutter sections to divert moisture away from the dwelling.

4.15.2 Energy Related Mold and Moisture

Moisture, mold, and mildew can seriously affect the health and safety of the client and crew. Steps must be taken to alleviate moisture problems. The West Virginia Weatherization Assistance Program will ensure that regular weatherization work is performed in a manner that doesn't contribute to the increase of any mold problems, and when the work is performed properly, can alleviate many mold conditions.

The Weatherization Assistance Program is not a mold remediation program. The use of DOE funds for the removal of mold and other related biological substances is not an allowable weatherization expense. If necessary, Weatherization Assistance Program services may need to be delayed until the existing mold problem can be corrected or referred to another agency for funding of remedial action.

The most common sources of moisture are leaky roofs and damp foundations from ground water. Other moisture sources include unvented dryers; unvented gas appliances such as ranges or decorative fireplaces; and showers in bathrooms without exhaust fans. One of the largest sources of household water vapor is the occupants themselves, through respiration and perspiration. Therefore, the number of people in the home is an important factor. The type of climate in the region is also important. A region that has a lot of rain and humidity, like West Virginia, or extreme temperatures is more likely to have a moisture problem.

The following steps are recommended in addressing moisture problems within the West Virginia Weatherization Assistance Program:

1. Assessment of Moisture Conditions.
    a. Prior to weatherization all homes will be inspected for previous or existing moisture problems. Identifying and eliminating the sources of the moisture should be the first priority when a moisture problem is found.
    b. The Mold and Moisture Assessment Findings form will be completed and given to the client and placed in the client file. Give special attention to the following areas:
        i. Look for evidence of condensation on windows and walls indicated by stains or mold. Inspect closets, especially those that are connected to outside walls. Clothes may need to be moved or removed in order to inspect the walls.
        ii. Check for any standing water, open sumps, open wells or “wet weather springs,” dirt floors, water stains, etc. in basements. Also, check to see if firewood is stored in any conditioned space or the basement and, with the client’s permission, remove the wood to a sheltered space outside. Ask the client if laundry is hung to dry indoors during the winter months.
        iii. Check for leaking water supply lines or waste pipes.
        iv. If there is a high efficiency furnace present, the condensate drain line should be installed in accordance with the HVAC installation standards.
        v. Inspect to determine if attic roof sheathing shows signs of mold or mildew.
        vi. Inspect the top plates of all walls and chase-ways while in the attic. Balloon frame type walls or bypasses, if left untreated, can move moisture from the basement or crawlspace directly to the attic.
        vii. Inspect the structure for the possibility of a “roof over.” If a newer roof has been installed over an existing older roof, then the crew must extend plumbing or exhaust any vents to the outside pipes through the new roof and properly seal the penetrations.
2. Existing Moisture, Mold or Mildew—Deferral of Service.
    a. If an existing moisture, mold or mildew problem is found, the agency must determine if the moisture problem can be fixed under the scope of weatherization

or if there should be a Deferral of Service because of the severity of the problem (typically 10 square feet or more of affected surface).

i. If it is determined that the problems are too severe under the scope of weatherization, a Deferral of Service form will be signed at the time of inspection and left with the client and a copy placed in the client file.
ii. Client education must be given to the client to inform them of the health and safety problems associated with mold or mildew and the possible self-help solutions they can perform at a later date.
iii. The agency should try to refer the client to other programs or agencies that may be able to assist in resolution of the problem.

3. Existing Moisture, Mold or Mildew—Elimination under Weatherization.
   a. If an existing moisture, mold, or mildew problem is found and the agency determines that the job can be completed or corrected under the scope of the Weatherization Assistance Program, then:
      i. The agency will have the client sign the Hold Harmless Statement informing the client of the existing problem(s), leaving a copy with the client and a copy in the client file.
      ii. Because air tightening may cause an increase in relative humidity, client education should include information about any adverse health effects if moisture problems are left untreated and also include possible solutions, including installing ventilation in accordance with ASHRAE 62.2-2010.
      iii. The agency will repair or eliminate the moisture problem and weatherize the dwelling in accordance with program regulations.
      iv. Containment of the work area is not necessary if the affected area is less than 10 square feet of surface area. Vacating people from spaces adjacent to the work area is not necessary, but is recommended when children less than 12 months old are in the house. People suffering from any health conditions should be kept away from the area being cleaned.
4. Repair or Elimination of Moisture Sources.
   a. In the course of weatherization, measures that help reduce the humidity levels in the house may be installed. Examples of these measures are venting dryers to the outside, venting existing bath or kitchen exhaust fans or installing moisture barriers on dirt floors. Repair of 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 done before the weatherization job is completed.
   b. Moisture problems can be reduced or eliminated by controlling the source of the moisture. This can involve:
      i. Installing a ground vapor barrier of six mil black plastic on a crawlspace floor.
      ii. Venting dryers to the outside of the dwelling.
      iii. Sealing the foundation.
      iv. Providing positive drainage away from the foundation.
      v. Repairing the roof, flashing, gutter, and downspouts.
      vi. Educating the client about the sources of moisture that they are able to control.
      vii. Removal of unvented space heaters.

c. 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 properly sized exhaust fan in the subject area and informing the client of the related moisture issues and the proper operation and use of the fan.

4.15.3 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 venting must be of rigid metal or PVC or flexible metal vent pipe. No more than two 90° elbows may be used in the vent system.
4. Dryer venting that exceeds six feet must be piped with four-inch diameter rigid aluminum or galvanized piping.
5. Ensure that there are no traps (sags) in the vent hose so that condensation does not occur, blocking the air flow to the outside.
6. The outside end of the vent hose must be capped with a self-closing vent cover.
7. Gas dryer vent pipe should not be installed with sheet metal screws or other intrusive fasteners that will collect lint (according to NFPA 54).

4.16 Ventilation Systems for Acceptable Indoor Air Quality

An ideal ventilation strategy provides spot exhaust ventilation where the moisture and other pollutants are created, and also provides dilution ventilation to the entire home to provide fresh air for the occupants.

ASRHAE 62.2-2010, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, will be used for the installation of ventilation systems, both local ventilation and whole-building ventilation.

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

1. Bathroom ventilation
   a. Should have on-demand fans that exhaust at least 50 CFM and are controlled by an on/off switch or a time-delay-shutoff switch; or
   b. Should have continuously operating 20 CFM fan. A continuously operating bathroom fan or a programmed intermittently operating fan may serve as the whole-building ventilation.
   c. If a bathroom does not have this amount of ventilation stated in 1.a. or 1.b. above, it must be provided or Appendix A of ASHRAE 62.2-2010 must be used for sizing whole-building ventilation.
   d. Installed fans must have a back draft damper at the fan, at the duct termination, or at both locations.
2. Kitchens ventilation
   a. Should have on-demand fans that exhaust at least 100 CFM and are controlled by an on/off switch. A vented range hood is required if the fan airflow is less than 5 kitchen ACH; or

b. Should have continuously operating fan that exhaust at least 5 ACH based on kitchen volume. A continuously operating bathroom fan or a programmed intermittently operating fan may serve as the whole-building ventilation.
c. If a kitchen does not have this amount of ventilation stated in 2.a. or 2.b. above, it must be provided or Appendix A of ASHRAE 62.2-2010 must be used for sizing whole-building ventilation.
d. Installed fans must have a backdraft damper at the fan, at the duct termination, or at both locations.
e. Make-up air should be provided for kitchen fans exhausting more than 200 CFM.

3. Whole-building ventilation operating continuously will be no less than 7.5 CFM per person + 1 CFM per 100 ft^2 of conditioned floor area. If the number of people living in the dwelling is not known, or if the number of bedrooms plus 1 is greater than the number of people, the number of bedrooms plus 1 will be used to determine the occupant number.
   a. This ventilation may operate intermittently, but
      i. The CFM airflow must be increased accordingly while the fan is operating. For example, a flow rate of 25 CFM for continuous operation would be increased to 50 CFM for 30 minutes-on-30-minutes-off operation.
      ii. The fan must operate at least once every 4 hours.
      iii. The fan must be controlled automatically.
      iv. The fan control must be appropriately labeled.
   b. If the bathroom and/or kitchen fans do not satisfy the requirement of 50 CFM and 100 CFM airflow rates, respectively, Appendix A (Alternative Compliance Supplement) must be used when sizing the minimum whole-building airflow rate.
   c. The whole-building ventilation may be a single exhaust fan, multiple exhaust fans controlled appropriately, or a balanced system such as a heat recovery ventilator. It may also be part of the furnace/central air-conditioning air handling system.
      i. Local bathroom and/or kitchen exhaust fans are permitted to be part of the whole-building ventilation system.
      ii. The system must be designed to operate during all occupiable hours. A readily available override control must be provided to the occupant.
   d. Whole-building minimum ventilation requirements will be determined with a spreadsheet method distributed by West Virginia GOEO.
      i. The infiltration credit will be calculated as part of the procedure and be based on ASHRAE 119 and 136, and
      ii. The alternative compliance supplement (Appendix A of ASHRAE 62.2-2010) will be included when bathrooms or kitchens do not meet the local ventilation requirements.
   e. Whole-building ventilation discretionary threshold.
      i. If the whole-building minimum ventilation requirement is 15 CFM or less, the energy auditor may decide to install a whole-building ventilation system or not. The reasons for not installing a ventilation system when the minimum CFM requirement is between 1 and 15 will be documented in the client file. This decision will be based on:

1. The moisture assessment of the dwelling,
2. The indoor air quality assessment of the dwelling,
3. The health of the occupants, and
4. Other factors deemed significant by the energy auditor.

ii. If the whole building minimum ventilation requirement is greater than 15 CFM, a system supplying the design ventilation airflow must be installed unless a written waiver is granted by West Virginia GOEO.

f. Installed fans must have a backdraft damper at the fan, at the duct termination, or at both locations.

4. Fan sound ratings
   a. Fan sound ratings will be equal to or less than the ratings in Table 4.1.

Table 4.1
Maximum Fan Sound Ratings

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

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

Source: ASHRAE 62.2-2010.

5. Ductwork
   a. Ducts outside of the thermal enclosure will be insulated to a minimum of R-8.
   b. Rigid ductwork with a smooth interior surface is recommended over flexible ductwork.
   c. Duct support
      i. Rigid ducts will be supported at intervals of 4 feet or less. Supports will have a width of at least 1½ inches.
      ii. Flexible ducts will be supported at intervals of 4 feet or less. The maximum amount of support between supports will be ½ inch per foot of horizontal run, or less. Supports will have a width of at least 1 ½ inches.
   d. Duct diameter will be equal to or greater than the exhaust fan outlet.
   e. Duct runs will be as short as possible and will have not more than one elbow of a maximum of 90 degrees.

f. Kitchen fan ductwork will be rigid, smooth metal of at least 30-gauge wall thickness.

g. Rigid ducts
   i. Metal-to-metal or metal-to-PVC connections will be fastened with a minimum of at least three equally spaced screws.
   ii. PVC-to-PVC joints will be joined with approved PVC cement.
   iii. In addition to mechanical fasteners, seal duct connections with UL 181B or 181-M listed material. *Exception: PVC connections.*
   iv. Rigid ductwork will be sized according to Table 4.2.

h. Flexible ducts
   i. Will not be bent around framing members of other objects.
   ii. Extend flex duct to its full length so that the excess length is no more than 5 percent.
   iii. When flex duct is run through confined spaces, do not reduce the diameter of the flex duct in order to fit it within the space.
   iv. Repair tears in flex duct vapor barrier using a recommended material.
   v. Attach sections of flex duct according to the manufacturer's recommendations.
   vi. Flex-to-metal or flex-to-PVC joints will be fastened with tie bands using a tie band tensioning tool.
   vii. Flexible ductwork will be sized according to Table 4.2.

Table 4-2
Prescriptive Duct Sizing*

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

* This table assumes no elbows. Deduct 15 feet of allowable duct length for each elbow.

+ Fan rating @ 0.25 inches of water column.

NL = no limit on duct length of this size.

X = not allowed, any length of duct of this size with assumed turns and fitting will exceed the rated pressure drop.

Source: ASHRAE 62.2-2010, Table 5.3, page 6.

i. Duct terminations, exhaust
   i. The termination collar will be at least the same equivalent size as the exhaust fan outlet.
   ii. Termination fasteners will not inhibit damper operation.
   iii. Exterior termination will be flashed or weather sealed.

iv. Galvanized hardware cloth with no less than ¼ inch and not greater than ½-inch hole size will be used to exclude pests.

v. Terminations will be at least 3 feet from any property line or any operable opening in houses and at least 10 feet from any mechanical inlet.

vi. Metal or other approved material will be used for the termination fitting for kitchen exhaust.

vii. All existing mechanical exhaust ventilation systems should terminate outside the building shell by extending the ventilation duct through the roof or sidewall. Soffit terminations should not be used.

j. Exhaust grille location

i. For local bathroom or kitchen exhaust, the grille will be installed in the space where contaminants are generated.

ii. For whole-building ventilation when other local bathroom and/or kitchen ventilation is present, the grille will be located in a central location within the main body of the dwelling.

iii. For whole-building ventilation when no local ventilation is present, the grille will be installed in the central bathroom with the highest moisture generation.

k. Furnace air handler ductwork used as whole-building ventilation, supply ductwork from the outdoors to the return plenum

i. System will be installed according to the manufacturer's instructions.

ii. Supply ducts will be attached as close to the system as possible while remaining in compliance with manufacturer's specifications.

iii. System will be set up to provide filtration of air before reaching the air handler system. Intake filters will be accessible for maintenance, will not produce ozone, and the occupant will be educated on how and when to change the filter.

iv. A motorized damper will be installed between the intake fitting and the return side of the air handler. The damper control will be linked to the programmed operation controlling device. This damper will be accessible for maintenance.

v. Intakes for supply air will be:

1. 6 feet above grade;
2. At least 10 feet from exhaust outlets, plumbing vent outlets, or combustion vent outlets;
3. Above local snow or flood line; and
4. 18 inches above an asphalt-based or flat roof.

vi. Airflow CFM contributing to whole-building ventilation must be measured during commissioning.

6. Attached garage exhaust fans

a. Any ventilation in garages will be exhaust only.

b. Leakage between the garage and the living area of the dwelling will be tested for leakage according to Section 16.8 on page 152.

7. Instructions, labeling, and client education[3]
    a. A ventilation system operation guide designed for the occupants (non-professionals) to explain why the system was installed and how to operate and maintain the system.
    b. This guide will be reviewed with the occupants.
    c. Controls will be labeled as to their function, unless that function is obvious (such as on-demand bathroom exhaust switches).
    d. Clients must be asked to sign a document attesting to the fact that they have been informed about the installed ventilation system.
8. Commissioning
        i. Airflows of local bathroom and kitchen fans and whole-building fans will be measured after installation to ensure that the design CFM airflow has been achieved.

4.17 Combustion Safety Testing

1. With the integration of blower door technology and dense-pack sidewall insulation, houses are being sealed tighter than ever before. In accordance with the "house-as-a-system" approach to weatherization, we recognize that there can be existing indoor air quality conditions that may be intensified by current air sealing techniques. Therefore, the following health and safety measures must be performed on all combustion appliances of homes to be weatherized:
    a. A CO test of undiluted flue gases must be done on all vented combustion appliances. If a CO level above 100 ppm as-measured or 200 ppm air-free is found in the undiluted flue gas sample, corrective action must be taken to reduce the CO to acceptable levels. If readings are detected above the minimum levels, no weatherization work is to be done until the problem is corrected.
    b. An ambient air test for CO must be taken on coal, wood, unvented heaters and gas cook stoves. If any ambient level of CO above 9 ppm is found, the source must be identified and the problem corrected.
    c. A gas leak detection test must be taken on all natural and LP gas appliances and supply lines. All gas leaks must be repaired before any work is done. Oil supply lines and components must also be checked for leaks.
    d. Spillage and breech draft tests on all Category I natural gas, LP gas and oil appliances must be performed under worst-case depressurization conditions to ensure adequate combustion venting.
    e. An inspection of the vent system must be completed to ensure that the proper size and type of pipe is used, the condition of the vent pipe is satisfactory, the clearance meets applicable codes, and the vent system is unobstructed.
    f. Test for backdraft and the potential for flue gasses to spill into the living space.
    g. Identify the combustion air source and make sure it is unobstructed and sufficient, as defined by NFPA code.
2. A detailed description of these tests can be found in Section 16.7 on page 147.
3. The local agency is responsible for any potential health and safety problems that will be compounded if prescribed conservation measures are installed. For example, if a

[3] Please refer to ASHRAE Guideline 24-2008, Chapter 13, Operations and Maintenance Documentation, for guidance.

furnace is emitting unacceptable levels of CO, it is likely that tightening the home would increase the problem. Therefore, this problem must be fixed before any air sealing is done.

4. Hold Harmless Statements.
    a. If some measures are too costly for the program to absorb, or outside the realm of normal Weatherization Assistance Program practices, they must be identified and explained to the client. A General Hold Harmless statement can be signed to allow weatherization work to begin, once remediation of the problem(s) have been completed. In summary, the Weatherization Assistance Program may not be able to afford complete renovations of the heating system to ensure the entire system is up to code. In some cases, deferral of weatherization services is appropriate. Any installations made by the Weatherization Assistance Program, however, will be made according to NFPA and NEC codes.
5. Unvented Space Heaters.
    a. A dwelling utilizing an unvented space heater as the primary heating source cannot be weatherized.
    b. In such cases, the Letter of Program Services Deferral Due to Site Conditions must be signed by the client.
    c. The auditor must explain the consequences of using an unvented space heater to the client.
    d. When the client has agreed in writing that they understand the policy and will not use the unvented space heater, weatherization may commence. A completed Hold Harmless Statement must be in the file stating that the client understands the dangers of using the space heater and agrees to use it only if there is a power outage and that they understand that they must provide combustion air to the heater.
    e. Although code allows unvented space heaters in bathrooms and bedrooms the West Virginia Weatherization Program does not permit these installations due to moisture concerns.

4.18 Carbon Monoxide Alarms

1. At least one CO alarm must be installed in each weatherized dwelling, preferably one on each floor. Follow the manufacturer's recommendations for locating and installing the alarm. Typically, alarms are installed where the clients spend most time, such as near bedrooms. If an entire multi-family building is to receive weatherization services, a CO alarm should be installed in each unit of the complex.
    a. Combustion appliances are defined as any piece of equipment (such as a water heater, cook stove, or heating system) that burns a fuel such as wood, kerosene, oil, natural gas, or propane.
    b. Unvented space heaters are expressly prohibited in weatherized homes unless they are a secondary heat source.
2. All installed CO alarms must:
    a. Be UL 2034 listed.
    b. Have an electrochemical sensor with a 5-year warranty.
    c. Be a plug-in type with a battery backup or battery operated units with a 5-year warranty.

   d. Have a sensor life monitor that alarms after 5 years or at the expiration of the useful sensor life.
   e. Have a digital LCD display.
   f. Sample ambient air at least every 2 minutes.
   g. Have an alarm of 85 decibels at 10 feet.
   h. Be capable of displaying: the current CO level detected from 1 ppm to 500 ppm CO, the peak level detected, the total time peak level was recorded.
3. Customer education is a vital part of protecting households from the dangers of CO. Ensure that client education regarding the potential hazards of combustion appliances is delivered.
4. The cost of the CO alarm or combination CO and smoke alarm is a health and safety material cost.
5. Replacement of operable CO alarms is not an allowable expense.

4.19 Smoke Alarms

1. If smoke alarms are inoperable or non-existent, at least one alarm must be installed in each weatherized dwelling on each floor. If existing hard-wired smoke alarms are inoperable or broken, they must be replaced with comparable units.
2. Replacement of operative smoke alarms is not an allowable expense.

4.20 Fire Hazards

1. Combustion Appliance Clearances.
   a. Crews must check for adequate clearance of space heaters, furnaces, and vents from combustible materials. If the clearance is not sufficient, corrective action must be taken insuring all applicable NFPA codes are followed.
2. Solid-Fuel Appliance Checklist.
   a. The Solid-Fuel Appliance Checklist addresses safety issues, including fire hazards, from wood and coal stoves. Issues relating to the stove, stove pipe, and chimney are addressed.

4.21 Building Structure

1. West Virginia Weatherization Assistance Program crews often encounter homes in poor structural condition. In some cases, Weatherization Assistance Program services have to be postponed until the dwelling is made safe and able to weatherize. Sometimes agencies coordinate their efforts with other programs to enable and enhance services. Too often, there is no other recourse for the home, and Weatherization providers are forced to do the best they can under the circumstances. Often the Weatherization Assistance Program is the referred agency for homes in dire need of repair. Sometimes air sealing and health and safety measures can also be considered building structure repairs; examples include patching a floor or wall and repairing a chimney.

2. Repairs required to ensure weatherization materials are protected can also be justified utilizing a NEAT/MHEA audit. If energy related materials are greater than $250 of DOE/DHHR funds (not to exceed $450), NEAT audit must be run to show cumulative SIR is greater than 1.
3. Typical structure repairs performed by Weatherization crews include:
    a. Sealing minor roof leaks;
    b. Minor floor, wall, and ceiling repair;
    c. Window and door casings; and
    d. Minor chimney repair.

4.22 Electrical Hazards

1. Knob-and-tube wiring.
    a. Where live knob-and-tube wiring exists, the following conditions must be met in order to install attic insulation:
        i. Wiring insulation must be intact and complete with no exposed areas and connections.
        ii. S-type fuses that match the size of the wiring must be installed if they do not already exist. Any modification of the electrical panel must have prior written permission from the client. The agency may wish to contract with a licensed electrician where questionable safety conditions exist.
        iii. When installing cellulose or fiberglass, there must be a minimum of 1-inch clearance from the wiring. With cellulose precaution must be taken to prevent the possible drifting of the product, which could result in contact with the wiring.
    b. The presence of knob-and-tube wiring, overloaded circuits, live bare wires, asbestos siding, or untreatable moisture in the wall cavities will be allowable reasons for not insulating exterior walls. If the problems can be corrected within reasonable means, the walls may be insulated.
2. Other standards related to electrical safety include:
    a. Junction boxes must be covered and their locations indicated on the rafters above before insulation is installed.
    b. Inspect the electrical wiring to determine type(s) of wiring present, its condition, routing, and circuit protection.
    c. Over-fused circuits should be corrected by installing the appropriate size circuit protector matched to the wire gauge. The following protection is required:
        i. Not more than 15 amps for #14 wire.
        ii. Not more than 20 amps for #12 wire.
    d. If the circuits continue to trip the breakers or blow fuses, work should be deferred until the problems can be corrected.

4.23 Refrigerants

Most, but not all agencies have at least one crew worker with EPA-approved section 608 type 1 certification. Several agencies have workers who are type 2 certified to work on heat pumps and add-on air conditioners. No work involving any refrigerant recovery will be done by anyone not having the appropriate EPA certification. EPA certification courses are offered periodically through the Community and Technical College.

4.24 Other Code Compliance Issues

All installations involving combustion appliances must be done according to applicable NFPA codes. The Weatherization Assistance Program is not always able to bring all combustion appliances up to code. If this is the case, explain the situation to the client.

The National Electric Code is also applicable for the West Virginia Weatherization Assistance Program in appropriate situations and installations.

4.25 Deferral of Service

There are some health and safety conditions that, until ameliorated, make weatherization of some dwellings unfeasible. In such cases, work for qualified applicants must be deferred. Weatherization agencies must attempt to resolve such issues, as well as pursue reasonable options on behalf of the client, including referrals. Please refer to Section 1.6 on page 2 for more information regarding deferral of service.

While program workers have been historically reluctant to defer services, it should be remembered that most agencies have a very long waiting list of approved applicants, and there are typically many homes on the waiting list that are suitable, adaptable, and in dire need. This statement being made, it must be the goal of weatherization agencies to do all that is reasonable within their means to overcome problems and provide program services.

The West Virginia GOEO has devised a standardized form for deferral of services. Agencies should modify the form as needed for their particular circumstances. A significant part of this deferral policy is based on health and safety considerations.

4.26 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 will be done to the extent allowed by law.
5. Documentation in the client file is required regarding any of the above exceptions.

5 Client Education

5.1 Client 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 and/or what will happen next.
        iv. Brochures explaining how the client can save energy are to be mailed with weatherization acceptance letter.
    b. During the initial field inspection, education efforts should cover:
        i. What the client should expect during the inspection.
        ii. Air leaks discovered with the blower door.
        iii. An explanation of any appropriate health and safety issues, such as:
            1. Lead-based 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. Installed ventilation per ASHRAE 62.2-2010.
        iv. An explanation of energy conserving measures that will be installed, including:
            1. Air sealing.
            2. Addition of insulation.
            3. Heating and cooling 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.
            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 four years by a technician with an instrument capable of measuring carbon monoxide. This checkup and tuning should include: Testing of the range's gas pressure and 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; 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.

vii. An explanation of required maintenance for existing equipment, added equipment, or energy-saving measures.
1. All oil-fired heating units should be cleaned and tuned once every year.
a. If there is an oil-line filter, educate client on how to change the oil-line filter (filter will be replaced during energy audit and 2 will be left with the client).
2. All gas-fired heating units should be cleaned and tuned once every three years.
3. Inform client how to replace filter in heating and/or cooling air handler.

viii. What will take place after the initial inspection:
1. Order of events and when they will take place.
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.

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 reduce the client's energy bill and enhance thermal comfort.

d. The quality control inspection.
ii. The inspection personnel should reinforce the advantages of the energy-saving measures installed.
iii. The client should always be asked if they have any remaining questions regarding the weatherization or health and safety work that was done.

iv. 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. Work to establish the trust and respect of the client; this will make educational efforts more effective.
3. The use of up-to-date written materials is encouraged for client education, but demonstration has proven to work better in most cases.

5.2 Certified Energy Educator

1. Each agency will identify at least one Energy Educator, who attends a day long training utilizing role-playing, participation, and discussions to acquire the skills to establish an effective means of communication between the Energy Educator and the client. After passing a certification test, the Energy Educator will work with clients to affect change in bad energy conservation habits.
2. The Energy Educator will utilize a tabletop easel with energy saving tips and maintenance tips for weatherization measures. The process is intended to be interactive between the Energy Educator and client.
3. A key element of the process is a "contract" called the Energy Saver's Partnership Plan, where the client agrees to do certain actions to conserve energy in their home. The Energy Educator will follow up in two months to help ensure the "contract" is being heeded.

5.2.1 Energy Education Certification Form

The first section of the Energy Education Certification Form is used to document that an energy educator reviewed energy saving issues with the client. The second part of the form is a checklist to record the energy saving information and tips discussed with the client, and to review measures that were performed on the dwelling.

5.2.2 Energy Savers Partnership Plan

The Energy Saver's Partnership Plan is an agreement between the local agency and the client outlining what the Weatherization Assistance Program will do/did to save energy in the dwelling, and in turn, what the household agrees to do in regards to energy saving tips and preserving the weatherization measures. The form is intended to encourage the household to be more concerned with energy efficiency and understand why it will benefit them.

5.2.3 Energy Education Kit

All certified Energy Educators will have a kit containing certain "weatherization items" in order to aid them with the task of providing thorough client education. All items should be of the type/brand which the agency normally uses during the regular weatherization of dwellings. Only measures that have been installed or will be installed should be discussed with client.

Contents of energy education kit:

1. Incandescent and CFL light bulb: Utilized for comparison purposes; it is important that the client understand the benefits and energy savings associated with CFL bulbs.

2. Baggies of insulation: Two one gallon zip locking clear plastic bags, one filled with fiberglass and the other with cellulose. These will be used to explain to the client the insulation type, where it was installed, and the benefits.
3. CO and Smoke Detector: Explain to the client what each looks like, where they are located, and what action should be taken if either alarms.
4. Furnace filter: Explain and demonstrate how and where to install and the frequency of cleaning and/or changing filter.
5. Thermostat: Indicate the optimal energy saving temperature setting on existing thermostat by demonstrating how to set.
6. Floor registers: If fins have been removed explain to client the reason for removal and the importance of keeping them free of restriction due to furniture placement.
7. DHW wrap and pipe wrap: Explain to customers what measures have been installed and the benefits of each.
8. Low-flow showerhead: Explain benefits of installation.
9. Weatherstripping: Explain why installed and importance of leaving in place.

5.2.4 Certified Energy Educator Activities with the Client

1. The certified energy educator from the agency should make an appointment to visit the client.
   a. It is strongly recommended that the educator visit the client just before the weatherization work is completed. This is the most effective time for client education.
   b. If it is not possible to schedule the education visit before the weatherization work is completed, the visit should be scheduled within three days after the work is completed.
2. The educator should spend time developing a trusting relationship with the client. Other important activities with the client include:
   a. Discussion of the weatherization and health and safety work done on the client's home.
   b. Demonstration, if possible, of any of the work done or of energy-saving measures in which the client can engage.
   c. Presentation using the Energy Education flip chart.
   d. With the client, discuss, fill out, and sign the Energy Saver's Partnership Plan, suggesting two or three ways the client can commit to saving additional energy in their home. Leave a copy of this Plan with the client and make sure a copy is put in the client's file.
   e. Complete the Energy Education Certification and make sure it is put in the client's file.
   f. Discuss Client Education brochure and leave with the client. This brochure is a brief summary of the Energy Education flip chart.
3. It is recommended that the educator visit the client again in two to three months to check on the client's progress on the partnership agreement and reinforce the client education.
   a. Discuss with the client the Energy Saver's Partnership Plan agreement and their progress.
   b. Complete the Client Education Follow-Up Report and make sure it is put in the client's file.

6 Air Sealing

6.1 Air Sealing Requirements

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

During the air sealing process, a blower door must be set up so that the effectiveness of air sealing can be determined by measuring the reduction in the dwelling CFM50 value, unless a health and safety or structural integrity issue is present. This should be done at least two or three times during air sealing; at a minimum of once daily. A minimum of one blower door reading must be recorded in the Work Plan on each day unless a non-related measure is performed.

Clients should be educated on the necessity and reason for blower door testing. If a solid fuel appliance is utilized by the client, arrangements should be made prior to weatherization to ensure required readings are obtained and effective and efficient air sealing is accomplished. The auditor should inform client during the initial audit that blower doors readings will be required daily.

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.

Prior to any work done on the dwelling, an "as-is" blower door test should be performed as a means of determining the initial CFM50 and locating air leaks. "As-is" is defined as the configuration of the dwelling during the heating season (interior doors open, exterior windows and doors closed). Defining thermal boundaries to include basements as part of pressure/thermal boundary requires the "as-is" condition to be measured with the basement door open. Window air-conditioners that remain in windows year round should stay in window during the blower door test.

Air sealing work on dwellings is of two types:

1. Primary air sealing. This includes:
    a. Any obvious air sealing. Examples include replacing window glass where glass is missing, and sealing large holes in the building enclosure. There is little question that sealing or repairing these obvious leaks in the dwelling enclosure will be cost-effective.
    b. Air sealing that must be done prior to other high priority measures, such as air sealing the attic floor before insulation is added.
2. Secondary air sealing. This is air sealing completed with the guidance of the blower door after all primary air sealing activities have been completed, and typically after attic insulation and dense-pack sidewall insulation have been installed. Further description is provided in Section 6.4 on page 63.

6.1.1 Blower Door Use Requirements

1. Pre- and post-weatherization CFM_{50} measurements must be completed on each dwelling unit and documented in each client file on the Residential Audit Tool and Work Plan.
    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. If the solid-fuel appliance has been shut down for a shorter period of time, wet newspapers may be utilized to ensure that ash or flame is not carried into the living space.
iii. Suspected friable asbestos-containing material may be significantly disturbed. Friable asbestos is defined as material that easily crumbles into very small particles with very little force, such as finger or hand pressure. Friable asbestos is more dangerous than hard asbestos because of its ability to release very fine fibers into air which lodge into nose, windpipe, and lung tissue.
iv. Other documented extenuating circumstances.

2. Blower door testing should always continue during air-leakage reduction work as part of blower-door-guided air sealing.

6.2 Air Leakage Reduction Standards

1. The West Virginia Weatherization Assistance Program uses an Air Sealing Target Range and the Depressurization Tightness Limit for air sealing activities. These values must be entered into the Residential Audit Tool/Work Order after the blower door pre-test.
   a. The upper limit of the target range is the minimum acceptable CFM_{50} reduction based on percentage reductions from the pre-weatherization CFM_{50}. These reductions should be easily attainable in most cases. Greater leakage reductions should be sought, especially when the pre-test CFM_{50} is high. This reduction guideline is specified in CFM_{50} Reduction Guidelines for Upper Limit of Air Sealing Target Range, found in Table 6.1 below.
   b. The low air sealing limit will be the Depressurization Tightness Limit (DTL), expressed in CFM_{50}, or 1000 CFM_{50}, whichever is the greater value. Please see Chart 6.2 below and refer to Section 16.3 on page 141 for the details of calculating the DTL.

Table 6.1
CFM_{50} Reduction Guidelines for Upper Limit of Air Sealing Target Range

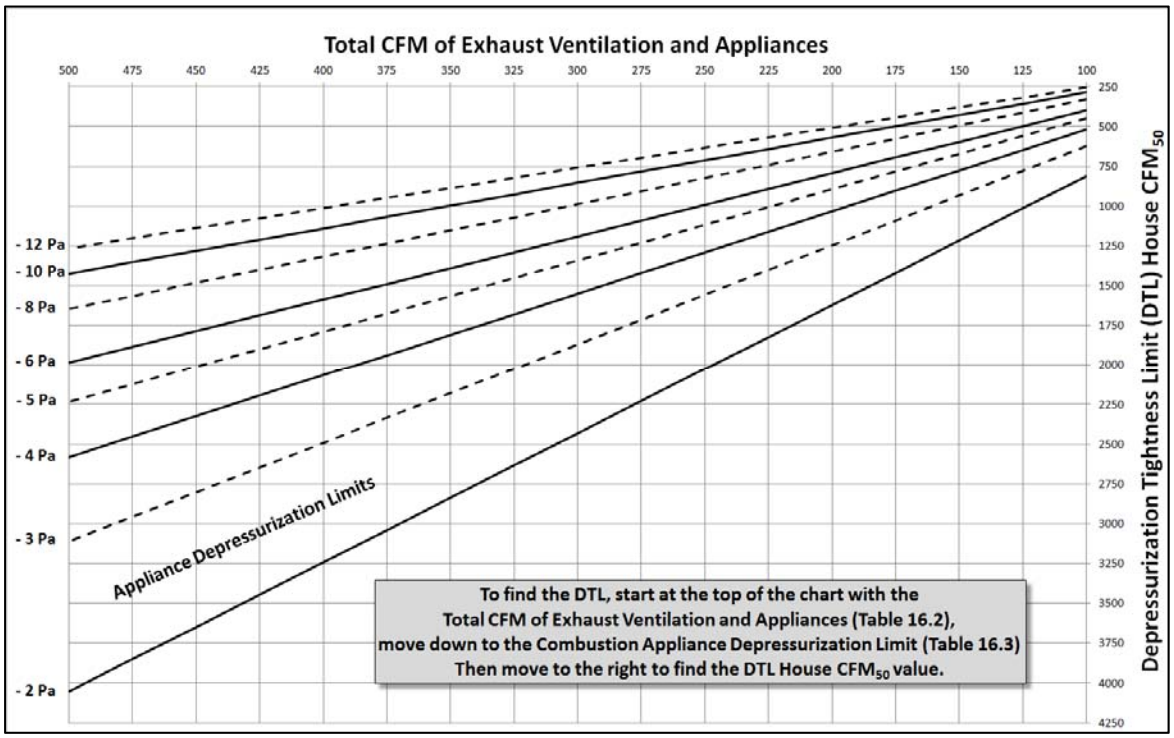
Pre-Wx CFM_{50}	Upper Limit of Target Range	Pre-Wx CFM_{50}	Upper Limit of Target Range
1,600	1,500	5,100	2,933
1,700	1,500	5,200	2,990
1,800	1,530	5,300	3,048
1,900	1,615	5,400	3,080
2,000	1,640	5,500	3,100
2,100	1,680	5,600	3,125
2,200	1,760	5,700	3,150
2,300	1,800	5,800	3,190
2,400	1,840	5,900	3,245
2,500	1,850	0006,	3,280
2,600	1,885	6,100	3,300
2,700	1,925	6,200	3,333
2,800	1,960	6,300	3,386
2,900	2,030	6,400	3,440
3,000	2,080	6,500	3,470
3,100	2,130	6,600	3,500
3,200	2,160	6,700	3,518
3,300	2,228	6,800	3,570
3,400	2,295	6,900	3,623
3,500	2,318	7,000	3,650
3,600	2,340	7,100	3,675
3,700	2,405	7,200	3,690
3,800	2,440	7,300	3,725
3,900	2,470	7,400	3,740
4,000	2,500	7,500	3,750
4,100	2,563	7,600	3,800
4,200	2,600	7,700	3,850
4,300	2,640	7,800	3,900
4,400	2,670	7,900	3,950
4,500	2,700	8,000	4,000
4,600	2,760	8,100	4,050
4,700	2,820	8,200	4,100
4,800	2,880	8,300	4,150
4,900	2,818	8,400	4,200
5,000	2,875	8,500	4,250

2. In performing mandated measures of air sealing, attic insulation, wall insulation, duct sealing, and mobile home floor insulation, some dwellings may become more airtight than the DTL. In such cases, proper appliance venting and acceptable indoor air quality must be ensured.

3. If any unvented space heaters or kerosene heaters are to remain in the dwelling after weatherization (only unvented heaters that are a secondary source of heat may remain), the auditor and/or crew supervisor must use caution when air sealing. Clients should be informed (educated) of potential hazards of using unvented secondary heating sources and the Hold Harmless Statement must be completed and signed. Please refer to Section 10.3.4 on page 105 for space heater policy.

6.3 Air Sealing Guidelines

Chart 6.2



Since energy audits normally do not prioritize measures within the general heat waste (infiltration) category, use the following guidelines for prioritizing air leakage measures. The technician should define the conditioned space of the home, and then try to establish an effective air barrier between the conditioned and unconditioned space. Measures are generally performed in this order until the air sealing limit is reached, or until it is no longer cost-effective to install additional materials. See Section 6.2 on page 60 for detailed instructions.

The blower door should be used to prioritize leaks from the largest to the smallest. Utilize the blower door to be more effective and efficient while assuring cost effectiveness. The blower door should guide all air sealing.

1. Air leaks are to be sealed from the largest openings first and progressively working to the smaller leaks. Due to the stack effect, the most critical leaks are often those in the top part and lowest parts of the house. Always check:
   a. Chase ways around chimneys.
   b. Plumbing and wiring penetrations.
   c. Interior wall cavities.
   d. Dropped ceilings.

e. Junctures between floors.
f. Electrical service entry.
g. Rim joist leaks.
h. Basement wall leaks.
i. Knee wall bypasses

2. Ensure all attic sealing is complete. Often the best method for detecting air leaks between the living space and the attic is by reversing the blower door fan to pressurize the house while the attic floor is inspected.
3. In mobile homes seal the plumbing chase behind washer and dryer, water heater closet, under/behind bath tub, and around the electric panel box.
4. Seal all large openings in the enclosure (e.g., holes in the walls, floors, or ceilings, missing sheetrock, missing or broken glass, missing windows, etc.).
5. Seal all duct leaks, both supply and return lines if the ducts are located in unconditioned spaces such as attics or crawl spaces.
6. Seal or install dampers in other openings such as dryer vents, kitchen and bathroom exhaust fans, window air conditioners, unused fireplaces and flues, etc.
7. Install dense-pack sidewall insulation in all walls separating conditioned living space from exterior or unheated spaces, using the standards described in these Standards. Attic and wall insulation should be installed before other air leakage measures are done to reduce the possibility of sealing the home below the air sealing limit, usually the DTL. A blower door test should be done to assess the status of the air sealing work. Continue air sealing if the air sealing limit has not been reached and it is cost-effective to do so. **NOTE: Always seal the attic properly before installing attic insulation.**
8. Continue "secondary" measures air sealing such as general caulking, weatherstripping, outlet seals, glazing, etc., as detected by the blower door. Secondary air sealing refers to those smaller leaks that receive a lower priority due to their relatively low air leakage reduction level reduction potential and/or high material/labor costs. Further description is found below.
9. Openings in recessed light fixtures must not be sealed unless the fixture is rated as a "Type IC" (zero clearance) fixture.

6.4 Secondary Air Sealing

Secondary air sealing measures are to be performed only after previously listed air sealing and insulation measures, and only when a need for this additional air sealing is detected by the blower door. If the CFM50 value is still not within the target range for the dwelling, these measures are normally performed by sealing the largest leaks first and then working down to the smaller leaks. If the target range has been met, these measures can still be performed if adequate CFM reductions are obtained. Following is a list of commonly performed secondary air sealing measures:

1. Tighten windows by weatherstripping or installing window channels. Re-glaze windows if there is noticeable air leakage, or if the window will likely deteriorate without re-glazing.
2. Seal doors with weatherstripping, sweeps, and thresholds. Make doors operate properly and replacement of entry locks as necessary.
3. Replace existing primary windows or doors if they are deteriorated beyond common repair methods. Any door, window, or sash replacement not yielding an SIR greater

than 1 should be considered a repair material, and is subject to the $250 Incidental Repair limit. If energy related materials are greater than $250 of DOE/DHHR funds, NEAT audit must be run to show cumulative SIR is greater than 1 (not to exceed $450). All window replacements must also be documented with pre- and post-weatherization photos in the client file. Please refer to Chapter 8 on page 87 for information about window replacements.

6.5 Air Sealing and Damming Around Chimneys and Vents

Special requirements are necessary for air sealing around chimneys and vent because of fire hazard. Follow the requirements below for such sealing.

1. Fire stopping around masonry chimneys "shall be of galvanized steel not less than 26 gauge thick or of noncombustible sheet material not more than ½-inch thick."[4] 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.
2. 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.
    a. 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.

6.6 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.
2. If the client does not remove the window unit, an air conditioner cover—interior or exterior—should be left with the client along with instructions of how to install and remove the cover.

6.7 Incidental Repairs

If energy related repair materials are greater than $250 of DOE/DHHR funds (not to exceed $450), NEAT audit must be run to show cumulative SIR is greater than 1. Repair materials are those that protect or enable the installation of "energy conservation" materials. Common repair materials include, but are not limited to, roll roofing, flashing, roof coating, and lumber for doors and window casings.

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

6.8 Room-to-Room Pressures

Room-to-room pressure(s) should be measured, with the air handler operating, in all rooms with forced air heating return or supply ducts and operable doors, after all weatherization installations have been completed, but before post-weatherization combustion safety testing (worst-case depressurization test) is performed. Measured room-to-room pressures should be lowered to 3 Pascals or less. Please refer to Section 11.2.3 on page 117 for more information.

6.9 Penetrations in Basement Ceilings

1. If the basement is defined as outside of the thermal enclosure, 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 depressurizing the house, closing the door to the basement, and opening a basement window or door to the outside.
    b. Sealing penetrations between a conditioned space (the first-floor area) and a space outside of the thermal enclosure (the basement) is allowable and saves energy.
2. If the basement is defined as within the thermal enclosure, 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 leaks that are connected to the outdoors:
    a. First, carefully complete all attic bypass air sealing.
    b. Insulate the attic after completing the attic bypass air sealing.
    c. Insulate the house walls. The walls must be dense-packed with cellulose unless conditions will not permit (examples that would prevent installation are asbestos siding or live knob-and-tube wiring).
    d. After completing the attic air sealing and the attic and wall insulation installation, depressurize the dwelling with the blower door.
    e. 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. If air is flowing through penetrations in the basement ceiling, this air is leaking in from the outdoors. Possible examples of these leaks include:
        i. Chimney chases.
        ii. Plumbing stacks.
        iii. Interior walls open to the basement.
    f. If basement ceiling penetrations are leaking air from the outdoors, seal them. Note: It is always best to stop these types of leaks by sealing attic bypasses or dense-packing exterior walls with cellulose. However, in some cases, difficult air leaks remain after this work.
    g. If penetrations are not leaking, do not seal them.

6.10 Zone Pressure Diagnostics

ZPD testing is required by the West Virginia GOEO Program in all cases where additional information is needed regarding the relative and absolute leakage of air barriers (pressure boundaries), including attics and attached or tuck-under garages.

1. Zone Pressure Diagnostics (ZPD) testing to assist in the determination of the location of pressure boundaries of the dwelling, the effectiveness of air sealing measures, and indoor air quality concerns is an effective tool. Please refer to Section 16.8 on page 152 for the details of ZPD procedures.
2. ZPD testing is required for:
    a. Verifying the effectiveness of attic air sealing.
        i. Post-weatherization leakage between the house and the attic (house-to-zone using add-a-hole ZPD method) should be 30 percent or less of the attic floor area. For example, an attic floor area of 1000 ft^2 should be tightened to 300 CFM_{50}.
        ii. If this air leakage cannot be measured with ZPD methods, the reason must be documented in the client file.
        iii. If this air leakage cannot be measured with ZPD methods, the reason must be documented in the client file.
    b. Determining the amount of air leakage between an attached or tuck-under garage, and then confirming air leakage has been reduced to an acceptable level by weatherization measures.
        i. Post-weatherization leakage between the house and garage (house-to-zone using open-a-door ZPD method) should be 200 CFM_{50} or less.
        ii. Exceptions:
            1. If the garage has been converted to a living space, this testing is not required.
            2. If the garage boundaries to the outdoors are not able to be fully enclosed, this testing is not possible, so is not required.
            3. The configuration of the attached or tuck-under garage makes ZPD testing impossible. For example, if an attached garage is also connected to the dwelling attic space. In such cases, the reason for not testing must be included in the client file.
        iii. If this air leakage cannot be measured with ZPD methods, the reason must be documented in the client file.

6.11 Duct Leakage

Duct leaks can lead to many problems in a dwelling, the most common one being wasted energy. Other problems can include thermal discomfort, substandard indoor air quality, and hazardous combustion venting. Please refer to Section 11.1 on page 111 for more information about duct leakage and sealing.

Duct leaks can be 1) within the confines of the thermal boundaries of the building or 2) outside of the thermal boundaries, perhaps leaking to the outdoors. Mobile home ducts and site-built homes with ductwork in crawl spaces or attics are susceptible to leakage to and from the outdoors.

Although duct leakage within the thermal enclosure 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 by performing the appropriate combustion safety testing.

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

Refer to Sections 11.1.6 on page 114 for Duct Leakage in Site-Build Homes and 11.1.7 on page 115 for Duct Leakage Standards for Mobile Homes and Double-Wides. Refer to Section 16.6.2 on page 146 for instructions for pressure pan testing.

All pre- and post-weatherization pressure pan testing measurements must be documented.

7 Insulation Requirements

Adding insulation to the building shell is often the most cost-effective measure performed in the Weatherization Assistance Program. Insulation reduces heat loss through the building shell. Combined with the home's air barrier, insulation forms the thermal boundary. The air barrier and insulation thermal boundary should always be aligned with each other. Insulation should be installed without voids or gaps and should be protected from moisture. It is vital that an accurate analysis of existing insulation is performed so that the Priority Lists and weatherization measures are applied appropriately. Insulation certification documentation must also posted in attics that is visible from attic access location. The R-values of common insulation materials are listed below in Table 7.1.

Table 7.1
R-Values Per Inch For Common Insulating Materials

Insulating Material	Avg. R-Value Per Inch
Mineral wool	3.2
Fiberglass batt	3.0
Vermiculite	2.7
Perlite	2.7
Cellulose, loose fill (open blow)	3.7
Cellulose, high density	3.4
Fiberglass (loose fill)	2.8
Rock Wool (loose fill)	3.0
Expanded polystyrene board (cut-cell surface)	4.0
Extruded polystyrene board (smooth cell surface)	5.0
Polyisocyanurate board, foil faced	6.0
Two-component polyurethane foam	6.0

7.1 Attic and Roof Insulation

Attic insulation in older homes is often both insufficient and ineffective due to poor installation, settling, subsequent work related activity, or unaddressed thermal bypasses. Attic insulation produces the best energy savings of any typical weatherization measure and often is the most cost-effective measure in terms of Savings-to-Investment Ratio.

7.1.1 Inspection, Preparation, and Repairs

1. Prior to installing insulation, a thorough inspection of the attic area must be performed.
    a. 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.
    b. 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. Additional descriptions of allowable and necessary repairs

are noted below. Attic sealing needs to be performed before insulation installation.

c. Attics should be tested for air leakage between the ceiling and attic space either by pressurizing the house with the blower door or using zone pressure testing. These tests should be conducted prior to, and then after, performing air sealing and installing insulation in order to determine the quality and completeness of the air leakage and bypass sealing.

d. All bypasses, such as plumbing and electrical chase ways and balloon wall cavities, must be thoroughly sealed before insulating.

7.1.2 Determining the Effective R-value of Existing Fiberglass Insulation

Voids in installed insulation must be accounted for when determining the existing R-value.

1. For existing insulation other than fiberglass:
   a. Measure the average thickness of the insulation. Multiply the R-value per inch from Table 7.2 by the average insulation thickness.
   b. Measure the area covered by insulation (the calculated value from the previous step) and the area and R-value of the voids. Use a weighted average calculation to find the effective R-value of the existing insulation/voids.
2. To find the effective R-value for fiberglass batt insulation, use the following procedure:
   a. Measure the average insulation thickness.
   b. Determine the condition of the installed insulation using the following ratings:
      i. Good – No gaps or other imperfections.
      ii. Fair – Gaps over 2.5 percent of the coverage area. This is the equivalent of a 3/8-inch space on one side of a 14.5-inch wide batt.
      iii. Poor – Gaps over 5 percent of the coverage area. This is the equivalent of a ¾-inch space on one side of a 14.5-inch wide batt.
   c. Look up the effective R-value using the table below:

Table 7.2
Effective R-Values for Fiberglass Batts

Measured Batt Thickness, inches	"Good" Effective R-value of 2.5 per inch	"Fair" Effective R-value of 1.8per inch	"Poor" Effective R-value of 0.7 per inch
0	0	0	0
1	3	2	1
2	5	4	1.5
3	8	5	2
4	10	7	3
5	13	9	3.5
6	15	11	4
7	18	13	5
8	20	14	5.5
9	23	16	6
10	25	18	7
11	28	20	8
12	30	22	8.5

Based on *Heat Transmission Coefficients for Walls, Roofs, Ceilings, and Floors* by Timothy James and William Goss, ASHRAE, 1993.

7.1.3 Moisture Inspection and Repair

1. Roof leaks and all other attic moisture problems will 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. No exhaust fan vents, combustion appliance vents, or plumbing stacks may terminate in the attic.

7.1.4 Attic Access

1. There must be access to the attic provided for quality control inspection and potential future needs of the client. Mobile homes must have a 4" inspection port to allow for a proper estimate. Four-inch plastic plugs should be utilized to plug the hole and allow for future inspection.
2. A gable vent on a hinged plywood or OSB door is considered adequate access.
3. An adequately sized gable vent held in place with screws (no nails) is acceptable if building a hinged door is impractical.
4. When it is necessary to install an interior attic access in the ceiling, it must be:
   a. Sized to provide reasonable access for inspection.
   b. Will be weatherstripped and insulated to the same level as the attic floor, or with at least 4 inches of extruded polystyrene (R-20).

5. 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 will be wet-cleaned (please refer to Section 4.14 on page 40 for more details). Photo documentation of all LSW must be in client file.
6. An attic ceiling access will 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, unless limited roof height restricts rigid material. In that case, thick fiberglass batts are allowable.
    a. Examples of approved attic access insulation dam materials include:
        i. Plywood of at least ¾-inch thickness.
        ii. Wood board of at least ¾-inch thickness.
        iii. Plywood of at least ½-inch thickness with ¾-inch by 2½-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.
7. If there are no interior accesses, at least one exterior access to each attic space will be left for inspection purposes. 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 will be weatherstripped and insulated to the same R-value as the knee wall. At least one latch will also be installed to ensure air tightness. If it is unreasonable to provide permanent access to all knee wall areas, the attic and/or knee wall area must be inspected by a certified quality control inspector before the area is sealed off. The insulation in the sealed knee wall area must be adequately documented in the client file with photo documentation. Refer to Section 7.1.6.3 on page 74 for more details.

7.1.5 Insulation Shielding and Blocking

1. All electrical fixtures will 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, Type IC light/fan combinations and closed junction boxes.
2. No insulation, including fire-rated insulation, will 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 will be left within the blocked area.
4. Metal blocking must be notched so that it does not contact electrical wiring.
5. Fire stopping around masonry chimneys "shall be of galvanized steel not less than 26 gauge thick or of noncombustible sheet material not more than ½-inch thick."[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

[5] NFPA 211 *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*, 2006 ed., 7.1.6.3

flow of air and water vapor into the attic from these gaps or chases. One- or two-part foam is not an approved material for sealing around chimneys unless it has a flame-spread rating of 25 or less.

a. In addition to stopping the flow or air around a chimney, a dam 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 the dam 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.

7.1.6 Installation Methods for Attic Insulation

1. Locate and seal attic thermal bypasses, chases, and open-topped partition walls. Remove enough of any existing flooring so that a thorough inspection for, and repair of, attic bypasses is possible. Properly treat ceiling height changes and stairwells as necessary to stop air leakage. Seal knee wall floor cavities. Make sure bypasses are completely sealed before installing any insulation. Use zone pressure diagnostics to ensure attic is adequately sealed prior to insulating, document pre and post measurements.
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. Install soffit chute, dam, or other material to ensure the maximum amount of insulation is above the wall top plate. This chute or dam will also reduce wind washing.
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. If the installation of cellulose insulation on top of existing batt or blanket insulation is warranted, cut or pull back existing fiberglass batts one to two feet from the soffit and blow the perimeter.
7. Cellulose is the preferred insulation to be installed in the attics of site-built homes. If another type of insulation is installed, there must be documentation as to why cellulose could not be used.

7.1.6.1 Insulation Coverage and Density

1. Insulate uninsulated open-joist attics or any attic with R-19 or less existing insulation to at least R-38 in all dwellings that are heated and lived in year-round. Refer to Priority List for further guidance (see Section 3.8 on page 14).
2. 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 3.5 to 4.5 lb./ft^3.
3. Insulate knee wall cavities as follows:
   a. Blown cellulose at a density of 3.5 to 4.5 lb./ft^3.
   b. Fiberglass batts to an insulating value of R-19.

4. Where feasible, densely packing cellulose insulation with an appropriate hose or tube might help seal air leaks and bypasses in attics. However, dense-packing cellulose in an attic does not eliminate the need to remove enough attic flooring in order to find and seal leaks with caulking, foam, and other materials before cellulose in installed.
5. Calculating the number of bags, as per manufacturer's specifications from product supplied, is the preferred method for determining the proper amount and density of material to be installed into an attic area at a given R-value.
6. When it is cost-effective, it is preferred that dropped soffits above cabinets and similar construction details be filled with cellulose insulation.
7. When a vapor retarder is installed with the insulation, the retarder should be installed toward the conditioned living space.
8. Add insulation as necessary to eliminate voids and areas of incomplete coverage.

7.1.6.2 Vaulted or Sloped Ceiling/Roof Cavities

1. Vaulted ceiling or sloped ceiling/roof cavities will be insulated to a value of at least R-19 whenever possible. If it is not possible to insulate to R-19, the reason must be documented in the client file.
2. If batt insulation is used, the vapor retarder should always face the conditioned living space. If this vapor retarder faces a habitable space, the vapor retarder must be covered with a 15-minute fire-rated material, such as ½-inch drywall mudded once (for an air barrier). An air barrier without penetrations must be installed on the warm side of this insulation.
3. If cellulose insulation is used, the cellulose will be dense-packed in the vaulted or sloped ceiling/roof cavities.

7.1.6.3 Knee Wall Areas

1. Knee walls will be insulated in a manner similar to exterior walls when they separate conditioned from unconditioned spaces. Refer to Section 7.1.4, number 7 on page 71 for more detailed information regarding attic access.
2. Whenever possible, knee walls should be insulated with dense-pack cellulose insulation. Refer to Section 7.1.6.1, number 4 on page 73 for more detailed information regarding attic access.

7.1.6.4 Enclosed Ceiling/Floor Cavities

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

7.1.6.5 Storage Space

Where attic space is being used for storage before the attic is weatherized, the agency auditor should request the client remove storage items from the area before the crew begins the job. If storage cannot be removed or if the attic will be used for storage after insulation is installed, the agency can evaluate whether a storage platform should be built that will be supported at least 12 inches above the attic floor near the attic access, so insulation can be installed under the platform and storage items can be accessed without compromising the insulation. If client refuses to remove clutter, agency may defer service until attic is cleared.

7.1.6.6 Attic Ductwork Insulation

1. Ductwork in attics must be sealed appropriately with the proper materials (duct mastic) before insulation is installed. Refer to Sections 6.11 on page 66 and 11.1 on page 111 for instructions.
2. When working ducts are located outside of the thermal enclosure, install a minimum of R-8 on ducts and plenums.
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.
4. If ductwork outside of the thermal enclosure is serving a cooling system, the duct insulation must have a vinyl or foil vapor barrier installed on the outer surface of the insulation unless two-part foam is used to prevent condensation on the ductwork.

7.1.6.7 Floored Attic Insulation

If a drill-and-blow method is used for insulation in a floored attic, holes must be properly plugged, secured with adhesives, and sealed. Floor planks can also be removed to allow for access to blow cavities, and then reinstalled.

7.1.6.8 Attic Venting

Attic venting should be installed when needed, but no attic should be over-vented because this increases the overall leakage rate of the dwelling and can increase air leakage caused by the stack-effect. Sealing attic bypasses, controlling indoor humidity levels, properly sealing attic bypasses, and insuring exhaust fans are extended to the outside should be the primary means in controlling moisture in attics.

1. General Installation:
    a. Ensure that existing vents are not blocked, crushed, or otherwise obstructed. Correct problems as necessary, or replace.
    b. When attic insulation is installed, a reasonable amount of attic venting should be in place, unless local codes supersede.
    c. All vent openings should have suitable louvers and screens to prevent snow, rain, and insects from entering the attic.
2. High-Low Vents:
    a. Attic venting is most effective when there are equal amounts of low intake vents through soffits and eaves and higher exhaust vents on the roof.
    b. Roof vents should be installed close to the peak.
    c. Install high gable vents at least three feet above the soffit or a gable vent used for low venting.
3. Gable Vents:
    a. Gable-end vents should be installed as high in the gable as possible and positioned to provide cross venting.
    b. Precautions will be taken to prevent the wind from “washing” insulation near the attic vents.
4. Roof Vents:
    a. 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.

b. If possible, roof vents should not be installed on a roof that is in poor condition.
c. Roof vents are not to be installed over rafters.
d. Roof vents should be tucked under shingles as much as possible. Surface mounted roof vents are not allowed.

5. Knee Wall Venting:
   a. Knee walls or attic spaces that are sealed from other attic spaces may need to be ventilated as if they are separate attics.
6. Attic Vent Area Guideline:
   a. When attic venting is installed, use the following guideline:
   b. If the attic floor and bypasses are air-sealed and exhaust vent terminations extended to the outside, then one square foot of net-free venting may be installed for every 300 square feet of attic floor area. Existing venting net free area may be utilized as part of the requirement if location of vents is satisfactory and vents are open and in good repair.

7.2 Sidewall Insulation

Installing dense-pack sidewall insulation with uniform coverage and density is a proven energy-efficiency measure because it maximizes the insulating value, minimizes insulation settling, and effectively reduces air leakage though the walls. Dense-pack sidewall insulation must be completed where uninsulated wall sections exist, including walls that separate conditioned spaces from unconditioned spaces, such as garages or unheated porches. There must be complete documentation in the client file giving adequate rationale whenever walls are not insulated.

7.2.1 Inspection, Preparation, and Repairs

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 and then note them in the Residential Audit Form/Work Order.

7.2.1.1 Moisture Inspection and Repair

Any leaks or other moisture problems must be repaired prior to the installation of wall insulation. Make reasonable repairs to walls. Use lead-safe work practices in all pre-1978 dwellings where the presence of lead paint has been detected.

7.2.1.2 Interior Inspection and Repairs

1. Make reasonable repairs to interior walls as needed. In pre-1978 homes where the presence of lead paint has been detected, repairs to these surfaces can generate lead-based paint dust and debris, so lead-safe work and cleanup practices must be employed and documented. Locate any areas of the interior wall surface that are weak or not securely fastened. Holes drilled for insulation must be plugged, finished, and returned to a condition as close to the original as possible. See Section 79, number 2 on page 79 for other details.
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. Insulation should not be installed against chimneys and some electrical fixtures. Block around these areas before installing insulation. If it is not possible to block around an area, avoid that area when insulating. Make sure all appropriate code clearance requirements are considered.

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

7.2.1.3 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 and the presence of lead paint has been detected, lead-safe weatherization practices must be followed. Refer to Section 4.14 on page 40 for the details of lead-safe work practices.
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 audit. 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.

7.2.2 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 by adding interior finish material and insulating wherever possible, unless it can be proven not cost-effective to do so.
    a. If faced fiberglass batt insulation is used, the vapor retarder must face indoors.
        i. All vapor retarders must be covered with site appropriate permanent material such as ½ inch drywall.
        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.
4. As an exception, a nozzle may be used in small cavities such as above windows and doors, or in other spaces that are less than two feet in height.
5. The tubing method may be used to install insulation in the sidewall by drilling one hole per story.
6. Walls must be dense-packed whenever the interior wall surface material allows. Dense-packing requires:
    a. The proper machine settings. For dense-packing, the air-to-material ratio must be high enough for a cellulose density of at least 3.5 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.

b. 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 long.
   iii. Gradual reductions or transitions in the delivery system to minimize clogging.
   iv. A tube that is cut at a 45 degree angle at the end to facilitate insertion into the wall cavity.

c. A technician 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 one foot before the machine is turned on.
   ii. Pulling the tube out of the fill hole by just less than one 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.

7.2.2.1 Blocking

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 permanently retains the insulation.

7.2.2.2 Insulating Floor Cavities between Exterior Wall Cavities and Other Key Junctures

1. Open floor cavities between exterior wall cavities will be insulated in balloon-framed buildings.
2. Only those parts of these floor cavities that border the exterior must be insulated. 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.
3. It is recommended that these cavities be insulated using the bag method. This method uses an empty 100-pound grain bag or other appropriate material. The empty grain bag is pushed through the drilled hole at the rim joist area with the fill tube, filled with cellulose, and then the remainder of the bag opening is pushed into the hole with the fill tube.
   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 or another acceptable 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.
4. All key junction points must be properly dense-packed and/or air sealed including wall-ceiling intersections; cabinet insets; ceilings over tuck-under garages; and knee wall and floored attic intersections.

7.2.2.3 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 3.5 – 4.5 lbs/ft^3 using the tubing method, unless there is good reason not to dense-pack. If the insulation is not installed to at least 3.5 lbs/ft^3, documented reasons must be included in the client file.
3. When using blown fiberglass, install at a density of 1.6 lbs/ft^3. Cellulose is the preferred material for dense-pack sidewall insulation. Blown fiberglass would only be rarely used in a case where cellulose would not be an acceptable material.
4. Total voids of more than five percent will not be allowed by the West Virginia Weatherization Assistance Program.
5. It is usually not cost beneficial or practical to re-insulate stud cavities with existing fiberglass insulation. However all walls with existing insulation should be inspected in at least three stud bays to check for complete coverage. Do not assume all walls or stud bays are insulated just because some are. Infrared cameras can be utilized to ensure exterior walls are insulated adequately.

7.2.2.4 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. Holes drilled for an interior blow are to be covered by wooden chair rail and do not need to be sealed if dense-pack of the cellulose insulation (3.5 to 4.5 lbs./ft^3) is achieved.
3. Installing wall insulation by drilling and plugging exposed drill holes is an acceptable method when methods 1 and 2 above are not practical.
4. Plugs that are compatible with the siding or wall type must be used to fill and cover the exposed surface that has been drilled.
5. Exposed plugs must be caulked and primed and should be neat in appearance.
6. Any wood that is replaced as a result of the weatherization work and that is exposed to the weather must be primed.
7. 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.
8. Interior drill and blow techniques are preferred for homes with brick veneer siding.

7.2.2.5 Quality Control

A final inspection to assess quality and quantity of wall insulation must be performed. This inspection can be performed by using a borescope, removing interior outlet and switch plates, using an infrared camera, or other acceptable inspection techniques. The amount of installed insulation can also be checked by using the calculation methods based on square footage and cavity depth in the Residential Audit Form/Work Order. This final inspection should be performed by the agency quality control inspector and must be documented on their final signed report.

7.3 Foundation and Crawlspace Insulation

This section addresses rim joist insulation, basement insulation, and crawl space insulation. It has been found that insulating foundation walls in West Virginia is not cost-effective in most cases.

7.3.1 Moisture Inspection and Repair

1. All dwellings must be inspected for problems associated with excess moisture.
2. Identification of potential moisture problems will be documented in the client file with the Mold and Moisture Assessment Form and, if necessary, on the Hold Harmless Form.
3. Repair any moisture problems that will degrade or diminish the effectiveness of weatherization measures.
4. In crawl spaces, install a moisture barrier on the floor. This barrier should overlap at least six inches at the joints, and extend six 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 client file.
5. In unfinished basements that have potential safety problems due to slope, a non-skid moisture barrier should be considered for the client's safety such as roll roofing.

7.3.2 Wall Moisture Barrier

If there is evidence of water leaks or moisture coming through the foundation wall from the exterior, a moisture barrier must be attached to the sill plate in a manner that drains the moisture to the outdoor surface of insulation placed on the interior surface of the foundation wall, and covers the insulated section of the foundation or crawl space wall. Inspect guttering and downspouts and repair where appropriate.

7.3.3 Treatment of Other Hazards

Use appropriate personal protective equipment and work practices in the presence of animal or insect hazards. Ensure personal safety during work.

7.3.4 Defining the Thermal Boundary/Enclosure

The auditor must decide whether the first floor or the foundation wall will serve as the air and thermal boundary. A lived-in basement would always be considered within the boundary, but unused basements and crawl spaces can be within or outside of the boundary. In some cases making this decision will be difficult. The information below is intended to set guidelines for defining the air and thermal boundary for an unoccupied basement or crawl space.

1. The foundation walls are the preferred air and thermal boundary when:
    a. There is good ground drainage and no existing moisture problems;
    b. There is an interior stairway between the house and basement;
    c. There are ducts and the furnace in the basement;
    d. Foundation walls test tighter than the floor;
    e. Basement may be occupied some day;

f. Laundry facilities are in the basement;
g. Heating equipment is located in the basement;
h. Floor air sealing and insulation would be very difficult; or
i. There is a concrete basement floor.

2. The floor is the preferred air and thermal boundary when:
   a. There is moisture or excessive dampness in the basement with no practical solution for mitigation;
   b. No furnace or ducts are present in the basement;
   c. There is an exterior door only, with no door leading directly to the living space above;
   d. There is rubble masonry foundation;
   e. There is a dirt floor or deteriorating concrete floor;
   f. Foundation walls are badly cracked; or
   g. Excessive door and/or window repair is required in the basement.
3. Basements and crawl spaces should be tested using zone pressure testing 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.
4. Garages are never considered part of the conditioned living space.

7.3.5 Storage Space

The client needs to be advised to remove any items so that the floors can be insulated effectively. The agency can work with the client in the event the client is incapable of moving the items as needed. The agency has the right to defer service until issue is resolved.

7.3.6 Rim or Band Joist Insulation

1. Rim joist insulation must be justified with a NEAT audit.
2. Insulation must be a minimum of R-10.
3. Fiberglass, rigid foam board, two-part foam, or other appropriate insulation may be used for this application.
4. If there is significant air leakage, the band or rim joist area must be properly sealed before the insulation is installed.
5. The insulation must be secured in a permanent manner.

7.4 Floor Insulation

7.4.1 Inspection, Preparation, and Repairs

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

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 will be covered with a moisture barrier of six mil black plastic 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 will be documented in the client file.
4. Repair any moisture problems that will degrade or diminish the effectiveness of weatherization measures.
5. Repair any rotted, broken, or damaged structural components when appropriate.

7.4.2 Installation Methods for Floor Insulation

1. All appropriate air sealing of the floor should be done before insulation is installed.
2. Install R-19 insulation between floor joists that define a thermal boundary.
3. The insulation should be installed without voids or gaps. Fit insulation tightly around cross bracing and any obstructions.
4. Floor insulation must be fastened securely in place with wire fasteners, insulation hangers, nylon mesh, or another appropriate method. Friction fitting or stapling floor insulation is not considered an appropriate method for securing the material.
5. Do not support insulation with Tyvek, Typar, or other house wrap stapled to the bottom edges of the joists.
6. Do not use chicken wire or other metal mesh to support floor insulation.
7. Install insulation so that it is in contact with the underside of the sub floor above. Insulation should not be compressed when installed.
8. Faced fiberglass insulation must have the facing upward toward the heated area.
9. Ensure that floor insulation is in direct contact with the rim or band joints. If the dwelling is balloon framed, air seal the bottom of the stud cavities prior to installing the insulation.
10. A crawl space clearance of less than 18 inches from the bottom of the floor joists to the ground is considered inaccessible.
11. Combustible material must be kept a minimum clearance of six inches from any combustion appliance or flue.

7.4.2.1 Dryer Vents

Dryers must be vented to outside the perimeter of the crawl space or foundation. The outside end of the vent hose must be capped with a self-closing vent cover. Refer to Section 4.15.3 on page 45 for dryer vent details.

7.4.2.2 Materials

Fiberglass insulation, faced or unfaced, is the preferred insulation material for perimeter and floor. Vinyl faced insulation should not be used for floor insulation.

7.4.2.3 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.

7.4.2.4 Ducts and Pipes

1. When floor insulation is installed, ductwork below the floor insulation must be appropriately sealed and insulated. Refer to Section 6.11 on page 66 for instructions.
2. When floor insulation is installed, water pipes and all furnace supply and return ducts below the insulation must be insulated as part of the floor insulation measure. Please refer to Sections 7.4 on page 81.
3. Do not insulate over pumps, valves, pressure relief devices, or vents; do not insulate over heat tape unless the manufacturer's specification indicates that such installation is safe.

7.4.3 Crawl Space Venting, Site-Built Homes

1. Refer to Section 7.3 on page 80 for more information regarding crawl space treatment.
2. Crawl space venting is generally not needed if the following conditions are met:
   a. The crawl space is dry with no evidence of standing water or moisture problems;
   b. There is proper surface drainage;
   c. There is a properly installed moisture barrier covering the entire crawl space floor.
3. If the above conditions cannot be met, the crawl space must be vented. If a moisture barrier cannot be installed, the reason will be documented in the client file.
   a. If crawl space vents are provided, they must provide one square foot of free vent area for every 1500 square feet of crawl space ground area if there is a moisture barrier, or one square foot of free vent area for every 300 square feet of crawl space ground area if a moisture barrier cannot be installed.
   b. Crawl space vents will 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.
4. 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.

7.5 Electrical Safeguards

1. Correct electrical problems such as unsafe wiring, open junction boxes, or other electrical code violations prior to performing any insulation work.
2. In attics, all visible electrical junction boxes will be covered with an appropriate junction box cover and their location must be noted on the rafter above the box.
   a. All electrical fixtures will be blocked with rigid material to ensure a minimum insulation clearance of three inches and a maximum clearance of six inches. Exceptions to this rule include Type IC (insulation contact) recessed lights and light/fan combinations, and closed junction boxes.
   b. 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.
3. Knob-and-tube wiring:

a. If knob-and-tube wiring has been deactivated and the dwelling has been rewired with BX, NM, or other approved electrical cable, the attic may be insulated over the inactive knob-and-tube wiring.

b. Any insulation must be kept at least one inch from live knob-and-tube insulation, unless the wiring has been approved or upgraded by a licensed electrician.

4. Under floor joists do not use any metal mesh material, such as chicken wire, to support floor insulation. This can cause an electrical hazard to the installers.

7.6 Spray Foam Insulation

Polyurethane spray foam is available in one-part and two-part. One-part is usually used for smaller applications and will not stick adequately for overhead applications. Two-part foam is usually used for larger applications, such as knee walls and box sills. Both have good insulating qualities and do a good job of air sealing. Cost effectiveness must always be considered when using spray foam. This section primarily addresses two-part foam.

Most of the two-part foam insulation used for weatherization is closed-cell polyurethane (open-cell is also available). It is stored in liquid form, and consists of a petroleum based "A" side (primarily methylene diphenyl iisocyanate) and a "B" side consisting of polyols, catalysts, fire retardants, blowing agents, and other chemicals. The heat-releasing chemical reaction between the agents in the foam makes it tack-free within a few minutes, but depending on the mix and temperature of chemicals and the ambient temperature and relative humidity, it can take an additional 23 to 72 hours before the foam is fully cured.

Due to two-part foam's fire rating, it may not be left exposed in living areas. Check with local fire codes for more details.

The R-value of closed-cell two-part foam is generally from 5.5 to 6.0 per inch with a permeance of less than 1 for two inches or more.

7.6.1 Cost Effectiveness

The use of two-part foam can significantly increase the quality of weatherization if it is used wisely. The price of two-part foam is high, but significant reduction in labor costs and enhanced staff moral should be considered. Many weatherization programs have initially overused two-part foam, finding after the initial introduction that it was not the always the most cost effective way of insulating and air sealing. Once crews have experience with foam, the labor and material costs can be fairly accounted for based on experience. This allows for the determination of cost effectiveness.

7.6.2 Protective Clothing[6]

The use of protective clothing is necessary whenever there is a possibility of contact with two-part foam chemicals. The following is recommended:

1. Disposable coveralls allowing no exposed skin.
2. Disposable over boots with skid-resistant soles.
3. Gloves made of nitrile, neoprene, butyl or PVC.

[6] Please see http://www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html and www.spraypolyurethane.com for detailed information regarding safely using polyurethane foam.

4. Safety goggles or face shield.
5. Supplied-air respirator (SAR).

7.6.3 Problems and Limitations of Two-Part Foam

Because foam insulation is dependent on the mix of the chemicals and the proper curing, there are a number of details to keep in mind when using two-part foam insulation. These include shrinking, cracking, voids, fissures and bad adhesion. Try to follow these general rules:

1. Make sure the two chemical parts of the foam are at the proper temperature before beginning the application. Typically manufacturer's recommend the chemicals be stored and used at temperatures between 60° and 80°F.
2. The two parts should be applied in a 1:1 ratio. If this ratio is off, problems will result. Too much "A" results in a hard and brittle product. Too much "B" results in a soft and gooey product that is likely to give off excessive odor.
3. The surfaces should be "paintable" before the foam is applied. Clean the surfaces before application.
4. Apply closed-cell foam in layers (called "lifts") not more than 1 ½ inches thick. Allow a curing time of 10 to 15 minutes between lifts so that the heat from curing can dissipate before applying the next layer. Excessive heat can cause the foam to crack and shrink. Excessive odor after application is often an indication of excessive heat buildup.
5. Because two-part foam expands to approximately three times its original size, it cannot be used in closed cavities, especially around windows or doors.
6. Most two-part foams will fill a two-inch gap adequately. Larger gaps require backing material such as fiberglass.
7. Cured foam should not be exposed to UV light.

7.6.4 Where to Use Spray Foam Insulation

The typical uses for two-part foam include:

1. The backside of knee walls.
2. Knee wall/floor junction.
3. Attic bypasses sealing, including open-plate interior walls (stuff with a piece of unfaced fiberglass first), and around plumbing stacks and pipes.
4. Electrical penetrations.
5. On ductwork for sealing and insulating.
6. Box sill (rim joist, band joist) area. Check with local fire codes.
7. Crawl space walls. Be aware of moisture conditions and adhesion problems.

8 Window and Door Replacements

8.1 Primary Windows

8.1.1 Window Assessment

1. All existing egress windows must remain operable.
2. Non-operable windows may be permanently sealed against air leakage if agreed to by the client.
3. Window work on pre-1978 houses must be performed using lead-safe weatherization procedures.

8.1.2 Window Replacements

1. Window replacements must be based on an energy-saving decision process rather than on client requests or aesthetics.
2. Replacement of windows must be justified with the Weatherization Assistant audit and cannot be installed in lieu of a mandatory measure.
3. Window replacements must be documented in client file with a photo of the existing window before removal.

8.1.3 Window Air Leakage

Window tightening measures such as caulking and weatherstripping are considered general heat waste measures.

8.1.4 Window Repairs

1. When feasible, windows must be repaired, rather than replaced.
2. Replace missing, broken and severely cracked panes.
3. Window glazing compound will 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.
4. Jalousie windows in pre-1976 mobile homes can be replaced if they cannot reasonably be repaired and are significantly leaking air, such as a broken out glass or sash that does not seal to the frame and leaks badly. In this case, the replacements can be classified as air sealing measures rather than repairs. The replacement of jalousie windows can be done in addition to mandatory mobile home measures but cannot be done in lieu of those measures. Pre- and post-weatherization photo documentation is required in the client file.

8.2 Storm Windows

8.2.1 Interior Storm Windows

1. With the relative low cost of mobile home replacement windows and the unlikelihood that a storm panel would be cost-effective installed over a good quality primary window, replacement of a substandard window is generally preferred to the installation of a storm panel.
2. If interior storm panels are installed, they must be removable, the panels numbered, and the client educated to their removal, storage, and reinstallation. The supervisor must assess the ability of the client to comprehend this procedure and the likelihood that panels will be reinstalled correctly.

3. Self-storing insider storm windows can also be considered if MHEA justified.
4. Interior storm panels may be replaced or installed or primary windows may be replaced or installed, but both measures cannot be done to the same window unit.
5. A ½- to 2-inch air space between the prime window and the installed storm window is preferred.
6. Allowable storm windows include:
   a. Rigid-framed single- and double-strength glass.
   b. Rigid- and flexible-framed Plexiglas of at least 100 mils thickness.
7. Repairs to prime windows must be done to keep moisture out before an interior storm window may be installed over the prime window.
8. Storm windows must be securely fastened in place, installed straight, plumb, and level, and without distortion.
9. Storm windows must be installed with screws, placed at least every 16 inches, including one in each corner.
10. Metal storm windows should not come in contact with frames or fasteners constructed of dissimilar metals.
11. Installed storm windows in kitchens, baths, and other high moisture areas must be operable if they provide the only source of venting into the space.
12. Operable storm windows will move freely.

8.2.2 Exterior Storm Windows

1. Exterior storm windows can be installed as a last option when it is not cost beneficial to repair or replace the primary window and there is significant air leakage.
2. Storm windows are to be installed so that they function properly, and do not interfere with the operation of the primary window.
3. All storm windows over 32 inches in width and/or 63 inches in height must be installed with a brace bar for stability.
4. Storm windows must be installed with screws, placed at least every 16 inches, including one in each corner.
5. There must be a continuous bead of caulk sealing the storm window to the blind stop, or casing, without sealing the weep holes.
6. All exterior storm windows must have weep holes. If there are none, weep holes must be made.
7. A storm window should be installed so that there is less than a 2-inch dead air space between the glass of the primary and storm windows.
8. A double-hung storm window is not to be used as a horizontal slider.
9. A double-hung storm window is not to be installed over a dead light prime window.
10. Clips used in shipping storm windows are to be removed after the storm windows are installed.

8.3 Doors

8.3.1 Door Assessment

1. Doors must be assessed for needed repairs, air leaks and comfort-related problems.
2. If there are two or more existing egress doors on the first floor, at least two must remain operable. At least one egress door on the second floor, if existing, must

remain operable. Other doors can be sealed, if reasonable, with the client's permission.

3. Door work on pre-1978 houses where the presence of lead paint has been demonstrated must be performed using lead-safe weatherization procedures and photo documented according to lead-safe guidelines.

8.3.2 Exterior Door Replacements

1. Individual replacement doors may only be installed if the cost of the repair is justified by the NEAT or MHEA audit. Doors cannot be installed in lieu of mandatory measures.
2. Replacement doors may include one lite (pane of glass) if the replaced door had one or more lites.
3. Combination primary/storm doors can only be used if the door being replaced is a combo door. However, the same rules as number 1, above, still apply.
4. Door replacements must be documented in client file with a photo of the existing door before removal and of the replacement door.

8.3.3 Air Leaks in Doors

Air leak mitigation measures for doors such as jamb-up kits, sweeps, and thresholds must be based on detection of leaks using the blower door.

8.3.4 Door Repairs

1. When feasible, a door must be repaired rather than replaced.
2. Stuck doors do not have to be made operable unless they are to function as egress doors.

9 Mobile Home Requirements

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

9.1 General Inspection

Structural problems affecting insulation measures must be corrected prior to installing insulation.

9.2 Heating Systems

1. Perform a visual inspection.
2. Perform health and safety tests. Correct any hazardous situations and document. Try to insure there will be no unvented space heaters in operation in a mobile home.
3. Clean and tune the furnace to maximum steady state efficiency. Attach pre- and post-test tapes must be included in the client file.
4. Replace filters and leave one additional reusable filter with the client. Filter should be cut to size. Instruct the client on how to replace the filters.
5. If there is an oil-line filter, replace and leave 2 clean filters with the client. Educate client on how to change the oil-line filter.
6. Inspect thermostat to insure it is mounted in a proper location and is not the mercury bulb type switch.
7. Make sure all safety and efficiency tests have been completed and documented.

9.3 Moisture Problems

1. If there are moisture problems in the ceiling or sidewalls, insulation must 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, must be extended to the outdoors and sealed to prevent exhaust air from re-entering the conditioned space.
3. Dryer vents must be vented to the outdoors. If the mobile home is skirted, the dryer vent termination must be to the outdoor side of the skirting.
4. If the crawl space area has 18 inches of clearance or more between the crawl space floor and ceiling and the mobile home is skirted, install a moisture barrier on the ground in crawl spaces. This barrier should overlap at least six inches at the joints. Note: If the entire dirt floor is not accessible, cover as much as possible.
5. If the crawl space is a walk-under type, the agency has the option of not installing a moisture barrier, but only if there is evidence that the crawl space is used frequently by the client and is dry.

9.4 Electrical Inspections

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

1. Before insulating mobile homes, inspect and assess the electrical wiring and the circuit breaker/fuse box as follows:

a. #12 aluminum and #14 copper wiring must be protected with 15 amp fuses or breakers; and
b. The client must be asked about any known existing electrical problems.

2. 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.

9.5 Air Leakage Reduction

1. Refer to Section 6.2 on page 60 for Air Leakage Reduction Standards.
   a. Only the following air leakage reduction measures may be installed when the existing CFM_{50} measurement is below the Depressurization Tightness Limit (DTL) or 1000 CFM_{50}:
      i. Ductwork sealing.
      ii. Insulation preparation work and insulation installation.
      iii. Major repairs to the air barrier and thermal boundary.
      iv. Air sealing work that is necessary to block moisture migration into ceilings and walls.
2. Perform initial blower door test before any work is done to the mobile home. If the mobile home is looser than the DTL or 1000 CFM_{50}, repair any obvious, major leaks, utilizing the blower door to direct efforts.
   a. In addition to the leakage areas noted in number 1.a. above, major air leaks should be addressed, including the plumbing chase behind the washer and dryer, the water heater closet, under the bath tub, and around the electric service entrance conductor. 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 on the Residential Audit Tool/Work Order .
   b. Snap fasteners, weatherstripping, and/or drip caps should be used whenever possible to reduce air and/or water leaks around primary windows.
3. When accessible, the joint (marriage wall) between the two sections of a double-wide must be filled and sealed from underneath the structure.
4. Air leaks in water heater closets with an exterior wall must be sealed, with care taken not to seal off combustion air from the outside.

9.6 General Insulation

Insulation will be installed only in areas of the mobile home enclosure that separate conditioned from unconditioned space.

9.7 Roof/Ceiling Insulation

1. Recessed lighting fixtures and fan/light combinations that are Type IC (insulation contact) rated by UL may be covered with insulation.
2. Venting fan housings and ducts may be covered with insulation if all holes and penetrations are sealed with a nonflammable sealant. Fans must remain operational.
3. Thermal insulation will not be installed within three inches of fan/light fixtures or recessed light fixtures that are not rated Type IC.

4. All mobile home flues and chimneys must be listed for use in mobile homes to assure adequate clearances are maintained.
5. If fiberglass insulation is installed between the original roof and the added framed roof, ensure that there is no roof venting between the mobile home ceiling and the original mobile home room. If such venting is left it place it effectively short circuits the added insulation between the original and added framed roofs.
6. 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. All work must be completed with professional workmanship. Holes should be drilled in a straight line. The client must give approval to utilize this method.
7. If an exterior or side-opening (edge lift) installation method is used, all roof penetrations and areas of potential leakage must be sealed with elastomeric sealant (when compatible with roof materials) or another equivalent sealant, as necessary. Areas that are to be patched must be cleaned first, down to the metal roof surface. After insulation, install new mobile home guttering. The edge lift method is the preferred method to insulate mobile home ceilings.
    a. If the roof requires a new coating after this insulation work, make sure the roof is strong enough to support workers. Temporary walking boards are required rather than walking on the roof itself.
8. Installing insulation from the ridge of the roof is allowed.
9. If an end gable blow is utilized, steps must be taken to ensure complete and adequate coverage is achieved. Attention to areas behind gussets, trusses, edges and corners is critical. Access to the gable end should be achieved by removing siding. Drilling and cutting is not an allowable method for access. Gable blows are only permitted on A-frame construction.
10. 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.

9.8 Ductwork

1. General:
    a. Fiberglass (with the exception of duct board) will not be left exposed on the inside of ductwork.
    b. Visually inspect registers and boots where there is any evidence of air leakage.
    c. Repair any missing, loose-fitting, disconnected, or blocked ductwork. Repair work is warranted if there is restriction or blockage of the duct that restricts air flow, even if there is no indication of air leakage.
    d. Properly seal all detectable air leaks in duct system.
    e. Inspect, test, and repair, if necessary, the connection between the furnace plenum and the main duct run.
    f. Trunk-end stops are only necessary if it is determined that the installation will reduce duct air leakage.
        i. End stops will be made from a non-flammable material placed a minimum of 12 inches beyond the last register opening in order to retain balanced

airflow. If 12 inches is not possible, the minimum must be four inches. Gaps between the stop and the duct must be sealed with mastic. Use a pressure pan test to verify a tight seal.

g. Closable registers with vanes are not allowable. Existing closable registers must either be replaced with non-closable registers or have the operable part removed.

h. Flat non-reinforced registers are not allowed.

i. Floor registers must not be mechanically fastened to the floor except for situations where they may become a tripping hazard to the client.

2. Refer to Sections 11.1.6 on page 114 for Duct Leakage in Site-Built Homes and 11.1.7 on page 115 for Duct Leakage Standards for Mobile Homes and Double-Wides. Refer to Section 16.6.2 on page 146 for instructions for pressure pan testing.

3. Belly Return Conversions:

   a. Mobile home belly return air systems must be permanently sealed from the occupiable space. A living-space return air system must be created by:

      i. Installing an adequately sized return air grille(s) in the furnace closet door;
      ii. Sealing the return grilles in the floors of bedrooms, bathroom, kitchen, living area, etc.;
      iii. Sealing the return air grille in the furnace closet floor; and
      iv. 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 three Pascals or less. This can be done by undercutting doors, adding door or wall registers, or installing jump registers in the attic

   b. For ductwork sealing and insulation, follow the instructions in Section 11.1 on page 111.

4. Crossover Duct Repair and Treatment:

   a. Crossover ducts will be repaired or replaced 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 will be protected against rodents, pets, etc., and properly suspended above the ground. If replacement is needed, replace with hard line duct and insulate to R-8.

   b. Flexible crossover ducts will have a minimum R-8 insulation. They will 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 a comparable pressure-sensitive tape.

   c. Existing flexible crossover duct with an insulation R-value of four or less which has been damaged may be replaced with new foil-faced flexible duct with R-6 insulation.

   d. The crossover duct 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 and insulated.

e. Crossover ductwork must be appropriately secured above the ground. It may be supported by strapping or blocking.
f. Flexible duct will not be allowed to sag more than 12 inches over a span of eight feet.
g. Flexible duct must be foil faced since it is located in an unconditioned space.

9.9 Floor (Belly) Insulation

1. Floor Insulation Requirements:
   a. Repair and seal ducts before insulating the floor.
   b. Belly rodent barriers must be inspected for general condition, structural strength, and major air leaks prior to installing insulation.
   c. 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.
   d. Belly cavities must be inspected to determine the location of the plumbing, any plumbing leaks, and the R-value of existing insulation. Leaks must be fixed prior to weatherization. Additionally, determine if the mobile home has a hanging belly (floor joists run from one side of the dwelling to the other) or flat belly (floor joists run the length of the dwelling).
   e. Belly insulation will 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 6.11 on page 66.
   f. Belly insulation must be installed in a manner that ensures complete coverage of all heated areas.
   g. Holes that have been made in belly rodent barriers for the installation of insulation must be patched and sealed. One section of a three-tabbed shingle can be put into the cavity at the tube access point before insulating, and then moved into place to cover the slit in the belly after the insulation is installed.
   h. Bellies will not be dense-packed with cellulose or over-filled so as to create undue stress on the belly rodent barrier. Belly cavities should be blown to resistance, not dense-packed.
   i. If for any reason parts of a mobile home belly cannot be insulated, all other parts must be insulated, unless the parts that cannot be insulated will allow airflow to short-circuit the effectiveness of the insulated sections.
2. Floor Insulation Methods:
   a. Loose fill fiberglass is the preferred insulation material for mobile home bellies.
   b. Floors that have 6 inches of insulation or less should be filled entirely with insulation blown at the required densities. Other floor configurations must follow the Priority List for evaluation to determine the proper application. See Section 3.9 on page 18 for Priority List.
   c. Bellies that are greater than eight inches below the floor at the center area may be insulated using the perimeter method. If possible, leave space between water pipes and the floor to reduce the likelihood of frozen pipes.
      i. If clearance is less than 18 inches, belly should be insulated using the perimeter method.
   d. The preferred method for insulating bellies is from the edge.

i. When insulating a hanging belly (floor joists run from one side of the dwelling to the other), a 2½- or 2 $^{9}/_{16}$-inch hole should be drilled in each cavity. A rigid pipe or tube should be inserted to the opposite wing. The wings should be dense packed with fiberglass (1.6 pounds per cubic foot) and the center should be loose-filled (not dense packed.)

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

i. When insulation is installed from underneath the belly, it is preferred that the first person to go underneath install a six mil vapor barrier on the ground in order to reduce health risks to the installers from animal feces.

e. Make belly patches durable and secure by using adhesives, clinch staples, screws, and lath strips whenever possible. Large belly patches in the center of the belly should be made so that water will not accumulate in the event of a water leak.

f. 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. Soft patching materials that may be used include Tyvek and Typar. Patches should be adhered with silicon or other durable caulk and then stapled with clinch staples.

g. Ductwork must be inspected for insulation that might have accidentally been installed inside the ductwork during insulation work.

h. Upon completing insulation work, rim joists that have been drilled will be plugged with an appropriate plug. The plug will be sealed in the hole with an adhesive compound.

i. Venting crawl spaces should be considered only when there are existing moisture problems.

j. If a mobile home is fully skirted, a ground cover must be installed to prevent evaporation of ground moisture. If a mobile home is not fully skirted, a ground cover is not required.

i. Installing mobile home skirting is not an allowable measure.

9.10 Insulation of Water Supply Systems

1. Water pipes that have not been protected from freezing with under-floor insulation should be insulated to a minimum of R-3.
2. The piping will be free from water leaks and properly secured to support the weight of the piping and insulation.
3. The insulation product may be either a) flat and capable of being molded to the outside of the pipes, or b) preformed to fit standard pipe diameters. If the product is preformed, dimensions will be appropriate for the pipe size. Do not use fiberglass pipe wrap except in situations where preformed foam pipe wrap will not conform to the existing plumbing.
4. If the insulation is exposed to the weather, it will be resistant to degradation from moisture, ultraviolet light, and extremes in temperature, or a jacket or facing will be installed that protects the insulation from these conditions.

9.11 Water Heaters and Their Closets

1. At a minimum, water heaters in closets with an exterior wall must be treated as follows:
   a. The tank should be wrapped with an insulation blanket. Please refer to Section 12.1 on page 119 for instructions.
      i. Large holes in the closet walls that allow air leakage into the interior must be sealed.
      ii. All plumbing within the closet that is susceptible to freezing must be insulated.
      iii. An adequate amount of combustion air must be provided to gas water heaters.
   b. If it is not possible to wrap the water heater with insulation, the exterior access door and adjacent exterior walls of closets containing electric or gas water heaters should be insulated, if possible.
      i. Cover any air vents in the door or adjacent exterior wall.
      ii. Bring combustion air from underneath the belly or through any skirting by installing an appropriately sized metal or PVC chute with a rodent barrier when there is not a concentric flue.
2. When treating a water heater closet that houses a non-direct-vent gas water heater, air seal and insulate the interior walls and provide adequate combustion air.
3. Insulate first six feet of cold water pipe from the hot water tank and all exposed hot water pipe. Insulate any other cold water pipe exposed to freezing temperatures. Maintain clearances from combustible pipe insulation with gas water heaters.
4. Set hot water temperature to 120°F at the faucet nearest the water heater and educate client about how this will save energy, but might force shorter showers. If a dishwasher is present, set the temperature to 140°F unless the dishwasher has a pre-heater.
5. Install low-flow showerheads when shower flow exceeds three gallons per minute (one gallon in 20 seconds).

9.12 Combustion Systems

1. Always change the furnace filter.
2. If a furnace filter is replaced with a disposable filter, leave another washable filter behind with the client and instruct the client how to replace the filter.
3. If there is an oil-line filter, replace and leave 2 clean filters with the client. Educate client on how to change the oil-line filter.
4. All fuel-burning, heat-producing appliances in mobile homes, except ranges and ovens, must to be vented to outside. Further, all fuel-burning appliances in mobile homes, except ranges, ovens, illuminating appliances, clothes dryers, solid fuel-burning fireplaces and solid fuel-burning fireplace stoves, must be installed to provide for the complete separation of the combustion system from the interior atmosphere of the manufactured home (i.e., to draw their combustion air from outside.) Therefore, if interior combustion supply air is used for a furnace or water heater, replacement with a sealed combustion (direct-vent) furnace or water heater is required.
5. For replacement of solid-fuel burning appliances, please refer to Section 10.3.5 on page 106.

Optional measures should be evaluated on a case-by-case basis on the guidance in the mobile home priority list or MHEA for SIR justification. When these measures prove cost-effective, they may be installed.

9.13 Inside Storm Window Installation

1. The MHEA should be used to justify installation.
2. Panels must be removable, the panels numbered, and the client educated to their removal, storage, and reinstallation. This measure should not be done unless the job supervisor is assured by the client that they will maintain and reinstall panels correctly.
3. Self-storing insider storm windows can also be considered if MHEA justified.

9.14 Baseload Electricity Reduction

Electric baseload measures, as described in Section 12 on page 119, are to be considered for mobile homes, including refrigerator replacements, compact fluorescent light bulbs, and low-flow showerheads.

10 Space Conditioning Appliances

10.1 General Requirements

The efficient operation of heating and cooling systems is a critical aspect of efficient energy use. Replacing or repairing heating and cooling systems is allowed from an energy efficiency or health and safety standpoint. This section provides standards on the maintenance, repair, safety, efficiency improvements, and replacement of existing heating appliances.

All HVAC work must be performed by an agency employee, a contractor, or a subcontractor that has successfully completed the HVAC Technician course and certified. The person doing the HVAC work must be prepared to prove this certification at any time. All HVAC work must comply with all Standards and Best Practices.

10.1.1 Appliance Work Documentation

1. Each client file must include documentation of all efficiency work, adjustments, or replacements made to the water heating, space heating, and space cooling appliances.
2. Documentation must include information on the applicable combustion appliance efficiency tests (see Section 10.1.2 on page 99).
3. Before the work on a combustion appliance is complete, a representative of the agency must have completed a review of all combustion appliance forms and determined that the combustion appliance(s) meets the appropriate specifications.
4. All combustion appliances must be tested and documented in the client file. They should be tested “as found” and then after a clean and tune has been performed to ensure the appliance is safe.
5. If an appliance is not functioning and is not repairable, the reason for replacement must be documented on the client file. The furnace brand and serial number must be recorded, if present.
6. A pre- and post-combustion safety testing must be performed on all vented appliances. See Section 16.7 on page 147 for the details of required combustion safety testing.

10.1.2 Combustion Efficiency

1. The steady-state efficiency of all heating system should be checked to determine if the system needs cleaning and tuning.
2. Replace the heating system if the priority list or applicable conditions are met (see Section 10.3 on page 104).

10.1.3 Air Handler Filter Replacement

1. Replace filters and leave one additional reusable filter with the client. Filter should be cut to size. Instruct the client on how to replace the filters.

10.2 Health and Safety Measures for Combustion Appliances

With the use of blower door technology and dense-pack sidewall insulation, houses are being sealed tighter than ever before. In accordance with the “house-as-a-system” approach to weatherization, there might be existing indoor air quality conditions and combustion venting

problems that may be intensified by air sealing activities. As a result, the following health and safety tests and inspections apply to all homes to be weatherized.

10.2.1 Vent System Inspection

An inspection of the vent system must be completed to ensure that the proper size and type of venting pipe is used, the condition of the vent pipe is satisfactory, and the clearances meet applicable codes. Ensure that the vent system is unobstructed. Use Table 10-1 below for guidance. Refer to appropriate codes and manufacturer's instructions, if appropriate.

Table 10-1
Required Vent Types and Clearances

Gas	Oil	Solid Fuel
24 gauge single-wall galvanized 6 inches from combustibles	24 gauge single-wall galvanized 18 inches from combustibles	24 gauge single-wall black pipe 18 inches from combustibles
B-vent and BW-vent 1 inch from combustibles	Smoke pipe Type L double- wall PMI from combustibles	Smoke pipe Type L double- wall PMI from combustibles
Approved thermo-plastic for 80+ and 90+, 0 to 5 inches from combustibles PMI	Metalbestos all-fuel pipe 2 inches from combustibles	Metalbestos all-fuel pipe 2 inches from combustibles
Schedule 40 for 90+ condensing 0 inches from combustibles PMI	Stainless steel flexible liner must be installed as a kit	Stainless steel flexible liner must be installed as a kit
Flexible flue liner kit, must be installed as a kit	Residential vents must have a single acting barometric damper -.04 inches WC	
All horizontal sections of vent must have a ¼-inch per foot slope down to the appliance.		

1. Mobile home vents:
   a. There are no approved gas Category I, natural draft furnaces for mobile homes; however, there are some water heaters of this type. They will be clearly marked "Approved for Mobile Home Installation" and will have certain installation requirements.
   b. Prior to 1976, mobile home furnaces got combustion air from underneath the mobile home by a duct or hole in floor. These furnaces had a single wall flue pipe.
   c. Post-1976 mobile home furnaces must be sealed combustion. A sealed combustion mobile home flue is a double-wall concentric vent stack that routes flue gasses out through the inner stack and draws combustion air from the roof down between the inner and outer vent pipes.
   d. Vent repairs or replacements should be done according to applicable codes.

10.2.2 Appliance Clearances

Check for adequate clearance of space heaters, furnaces, and flues from combustion materials. If the clearance is not sufficient, corrective action must be taken to ensure all applicable codes are followed. Refer to appropriate codes and manufacturers' instructions, if appropriate.

10.2.3 Combustion Supply Air for Heating Appliances

Identify the combustion air source and make sure it is unobstructed and sufficient, as defined by the appropriate NFPA code. Use the method below to meet code requirements for combustion supply air:

1. The minimum volume of the combustion appliance zone (CAZ) is 50 ft^3 per 1000 Btu/hr. input rate of vented combustion appliances in the CAZ.
2. If combustion supply air is not adequate, correct the situation with the guidance of NFPA 31 (oil), 54 (gas), or 211 (solid fuel).

10.2.4 Combustible Gas and Oil Leaks

Gas leaks can be dangerous and are literally a total waste of energy. Additionally, natural gas and LPG act as a greenhouse gas that is about twenty times more potent than carbon dioxide. Check for gas leaks on all natural gas and LPG gas appliances and supply lines. Check for natural gas leaks above fittings; check for LPG leaks below fittings. All gas leaks must be repaired before any work is done. Verify gas leaks with a soap solution (note: do not use soap solution on flexible CSST tubing). Use a listed bubble solution for flexible CSST tubing. If a gas leak is found:

1. Severe gas leaks:
   a. Shut down the main gas valve at the gas meter, if it is outside.
      i. Inform the client and leave the dwelling.
      ii. Contact the fuel supplier and have the problem fixed.
2. Moderate gas leaks:
   a. Tighten the pipes and fittings (with gas supply off).
   b. Replace pipes that have holes or cracks, making sure all connections are properly sealed.
   c. Ensure that all materials and sizes comply with NFPA and local codes.
3. All gas leaks must be fixed before weatherization work begins. Document leaks and repairs in the Residential Audit Form/Work Order. Gas leaks on buried lines outside the house/thermal enclosure are not the responsibility of the Weatherization Assistance Program, but can be repaired when feasible.
4. Oil supply lines and components must also be checked for leaks. If leaks are found, repair in accordance with NFPA and local codes.

10.2.5 Combustion Safety Testing

Refer to Section 16.7 on page 147 for the details of combustion safety testing.

10.2.6 Carbon Monoxide Emissions, Ambient and Flue Gas

Carbon monoxide is a hazardous gas that is a common byproduct of both vented and unvented combustion. Testing for CO must be done to ensure the safety of clients and workers:

1. Ambient CO testing (please refer to Section 16.7 on page 147 for the details of combustion safety testing):
   a. Upon entering the job site living space, an ambient CO reading must be taken. If any level of CO above nine ppm is found, the source must be identified and the problem corrected. If a level of 9 ppm or higher is found, a Carbon Monoxide

Warning Statement must be filled out and discussed with the client. A copy is to be given to the client and a copy is to be inserted into the client file.

b. An ambient air test for CO must be taken on solid-fuel appliances, unvented heaters, and gas cook stove top burners. If any level of CO above nine ppm is found, the source must be identified and the problem corrected.

c. Post-weatherization CO readings must be taken and documented to ensure that weatherization measures did not exacerbate an existing CO problem.

2. In all vented combustion appliances, a CO test of undiluted flue gases must be done. If levels are above 100 ppm as-measured in the undiluted flue gas sample, corrective action must be taken to reduce the CO to lower acceptable levels. If a level of 100 ppm or higher is found, a Carbon Monoxide Warning Statement must be filled out and discussed with the client. A copy is to be given to the client and a copy is to be inserted into the client file.

3. For gas oven bake burners, CO must be checked at the oven vent termination in a sample of undiluted combustion gas. The reading must be less than 800 ppm air-free. The CO emissions increase and then peak just after burner start up, they then fall to a momentary plateau before the burner shuts down as part of the duty cycle. The reading CO ppm must be taken during this stable plateau. If readings are higher than those stated above, corrective action must be taken.

   a. If readings are detected above these levels:

      i. Immediately inform the client and fill out the Carbon Monoxide Warning Statement Form.

      ii. Determine the source(s) and cause(s) of the problem and document reading(s) in the Residential Audit Form/Work Order.

      iii. At this point no weatherization work is to begin.

      iv. A plan of action is to be determined based on the skill level of the crew and implemented to correct the problem before any weatherization work can continue. This may involve using a contractor.

      v. If for some reason the client refuses the corrective action, the job is to be terminated and a written explanation along with a completed Carbon Monoxide Warning Statement documenting the reason inserted in the client file.

10.2.7 Smoke and Carbon Monoxide Alarms

Please refer to Section 4.18 on page 51 for more information on carbon monoxide alarms and Section 4.19 on page 52 for more information on smoke alarms.

10.2.8 Solid-Fuel Heating Systems

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

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

1. No wood stove may be exhausted into an unlined masonry chimney. Chimney work is an allowable expense, however, if needed chimney work is not addressable with existing program funds, such wood stove configurations will be disconnected and the chimney penetration sealed before other weatherization work can proceed.
2. The following NFPA 211 requirements must be used for all solid-fuel heating system installations.
    a. Triple-wall or insulated double-wall vent connector pipe must be used within 2 inches of combustible materials.
    b. Double-wall vent connector pipe must be used within 8 inches of ceiling combustibles and must be kept at least 6 inches from wall combustibles.
    c. Single-wall vent connector pipe must be kept at least 18 inches from combustibles.
    d. If necessary, provide combustion air from outdoors to reduce negative pressure around solid-fuel appliances.
    e. Single-wall solid-fuel appliances must be kept at least 36 inches from combustibles.
    f. Stoves installed closer than 36 inches to combustibles must be double-wall, or combustibles must be protected by ventilated, non-combustible wall protectors.
    g. Stove clearances of less than 36 inches must be specified by the manufacturer and printed on a metal tag attached to the stove.
    h. For further information, refer to NFPA 211.
3. Wall and floor heat protection requirements.
    a. Wall and ceiling protection must be at least 26-gauge (0.013 inch) sheet metal with 1-inch spacers or other approved material.
    b. Floor protection must be:
        v. If there is at least 18 inches of open air space between the bottom of the solid-fuel appliance and the floor, use at least 24 gauge (0.024 inch) sheet metal.
        vi. If there is between 6 and 18 inches of open air space between the bottom of the solid-fuel appliance and the floor, the floor protection material should be ¼ inch cement board covered with 24 gauge sheet metal.
        vii. If there is less than 6 inches of open air space between the bottom of the solid-fuel appliance and the floor, the floor should be protected with 4 inch thick masonry blocks arranged with the holes interconnecting and open to allow free air circulation through the floor protector. The hollow masonry should be covered with 24 gauge sheet metal.
4. Replacement vent connectors will be single- or double-walled stovepipe of at least 22 gauge. Each joint must be secured with at least three sheet metal screws or equivalent fasteners with joints facing in the proper direction. Vent connector material installed in the living space of a dwelling unit must be either black or stainless steel. Galvanized vent connector will not be used in a living space because it emits toxic zinc vapors when heated.
5. Chimneys should be mechanically cleaned using a wire brush and rods manufactured for this purpose. Any stiff wire brush may be used to clean vent connector material. Chemical chimney cleaning products are not an allowable expense in the WV Weatherization Program.

10.2.9 Hold Harmless Statement

There may be instances when health and safety problems might remain after weatherization has been completed on a dwelling. These can include:

1. Repairs relating to combustion appliances that are too extensive or costly for the West Virginia Weatherization Assistance Program to remedy. An example is an aged, asbestos covered boiler.
2. Existing conditions in a dwelling that are beyond the control of the weatherization agency. Examples include the client use of unvented kerosene or gas space heaters as a secondary heat source.
3. Photo documentation of existing health and safety problems that remain is encouraged.

The Hold Harmless Statement is to be used to document existing potential health and safety problems that remain after the weatherization work is completed.

1. An agency representative must explain the problems to the owner, and in the case of a rental unit, the client.
2. The health and safety problem(s) and corrective measures the owner and/or client can take must be documented on the form with as much detail as possible.
3. The owner and agency representative must sign and date the statement.
4. A copy of the form must be given to the owner.

10.3 Central and Space Heater Replacement

Every effort will be made to repair the existing heating unit before replacement is considered. Replacement will be allowed only when the unit cannot be cost-effectively repaired or made to operate safely. Every effort must be made to get the maximum efficiency possible with an existing installation. Inspections must be done to ensure that wiring and chimneys are in good condition and that there are no obvious building code violations. All efficiency measures must be performed and documented.

10.3.1 Replacement of Heating Systems, General

Replacement of a heating system (furnace or space heater) is allowed when one of the following conditions exists:

1. The heat exchanger is cracked and a new one cannot be located or is cost prohibitive to install;
2. Major repairs total 2/3 or more of the cost to replace the unit;
3. The unit design is very inefficient or the unit is grossly oversized (justified by *Manual J*, NEAT, or MHEA), resulting in high heating bills or combustion air, venting, or clearances that cannot meet national, state, and local codes.
    a. A grossly oversized unit can be replaced under two conditions:
        i. The existing unit is 40 percent or more oversized based on *Manual J*, NEAT or MHEA.
        ii. If an existing unit is suspected of being 40 percent or more oversized and/or has an input greater than 100,000 BTU/hr. Written sizing justification must be included in the client file before it can be replaced.

4. Weatherization work causes the existing heating unit to become grossly oversized based on *Manual J*, NEAT, or MHEA.

10.3.2 Replacement Heating System Sizing

All gas, oil, and electric replacement units must be sized according to Manual J, NEAT, or MHEA.

1. Documentation of heating system sizing must be included in the client file.
2. Replacement primary heating equipment must not be sized less than 50,000 Btu/hr. input for residential applications and 40,000 Btu/hr. input for mobile home applications.
3. Heating systems should not be oversized by more than 25 percent.
4. If the calculated size is not locally available, using the next higher size appropriate for the job is permissible.

10.3.3 Furnace Replacement

1. Furnace replacements must have an annual fuel utilization efficiency (AFUE) of greater than 80 percent. Higher efficiency units are preferred. 90-plus, high-efficiency furnaces are to be installed whenever possible unless this higher efficiency cannot be justified.
2. Contact the West Virginia GOEO before any boiler replacement.

10.3.4 Space Heater Replacement, Excluding Solid-Fuel Appliances

1. Space heaters with low steady-state efficiencies must be replaced if justified by NEAT or MHEA. Space heaters can also be replaced if there are other conditions present that may justify replacement, such as health and safety considerations, multiple space heaters being replaced by one unit with significantly less BTU/hr. input, or other factors listed below. The justification must be documented in the client file.
2. In homes where unvented space heaters are the primary heating source and there is no repairable existing vented heat source, the agency must install a vented heating system. If this is not possible, no weatherization work may be done. In most cases, this will mean the installation of a direct-vent wall heater(s). This policy is based on the fact that weatherization of the dwelling will result in the probability of increased moisture and indoor air quality issues resulting from an unvented space heater.
    a. When an unvented space heater is replaced as the primary heat source, the old heater must be removed from the dwelling.
3. West Virginia strongly encourages removal of all unvented gas- and liquid-fueled space heaters and replacement with vented, code-compliant heating systems as a prerequisite to weatherization. However, unvented gas- or liquid-fueled space heaters may remain as secondary heat sources in single-family houses provided they comply with the International Residential Code and the International Fuel Gas Code. Funds may not be used to replace unvented secondary space heaters. Any unvented gas- or liquid-fueled space heaters that remain in a single-family house after weatherization:
    a. Will not have an input rating in excess of 40,000 BTU/hour;

b. Will not be located in, or obtain combustion air from sleeping rooms, bathrooms, toilet rooms, or storage closets, unless:
   i. Where approved by the authority having jurisdiction, one listed wall-mounted space heater in a bathroom with an input rating that does not exceed 6,000 BTU/hour, is equipped with an oxygen-depletion sensing safety shut-off system, and the bathroom meets required volume criteria to provide adequate combustion air;
   ii. Where approved by the authority having jurisdiction, one listed wall-mounted space heater in a bedroom with an input rating that does not exceed 10,000 BTU/hour, is equipped with an oxygen-depletion sensing safety shut-off system, and the bedroom meets required volume criteria to provide adequate combustion air.

c. If any unvented kerosene heater is left in the dwelling after weatherization, including a newly installed unit, a Hold Harmless Statement signed by the client must be completed and put in the client file. Client education must be provided on the limited use of the unvented space heater.

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

10.3.5 Solid-Fuel Appliance Replacement Policy

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

1. Replacement of a solid fuel appliance is allowed only when there is a crack in the heat exchanger that can cause a carbon monoxide problem or a fire hazard. All replacements must comply with the current NFPA 211.
2. There may be situations where the costs of a new installation or the repair of an existing installation may be too expensive for the Weatherization Assistance Program to incur.
   a. In some cases, the owner may have to be responsible for some or all of the costs for making a solid fuel appliance installation safe.
   b. In situations where an owner is responsible for making any health and safety repairs; a Hold Harmless Statement must be completed with an addendum describing each problem to be corrected. A copy must be left with the owner and a copy becomes a part of the client file.

3. Cost of repair and replacement of solid fuel appliances are to be charged to health and safety.
4. Replacement of solid fuel gravity furnaces, forced air furnaces, and boilers will not be permitted and are considered beyond the scope of weatherization. However, repair of existing units will be permitted.
5. Solid-fuel appliances in mobile homes:
    a. Replacement of solid-fuel appliances in mobile homes must be mobile home approved direct-vent stoves. Mobile home solid-fuel stoves and approved venting systems are expensive. The material costs for these measures can easily exceed the targeted 15 percent of the total material cost for the job allotted for health and safety, so careful consideration must be given to the replacement of mobile home solid-fuel appliances.
    b. A completed Solid Fuel Report Form is required for each solid fuel appliance and must be part of the client file documentation.

10.4 Air Conditioner and Heat Pump Replacement Policy

This policy addresses how the WV WAP approaches air conditioning and heat pump equipment. Although, the State of West Virginia is regarded as a heating State, energy losses from improperly maintained, poorly installed and designed cooling and heat pump equipment should not be disregarded by the WV WAP. The primary goal is to save energy in a cost-effective manner. Frequently, a significant amount of a home's energy burden can be attributed to poorly functioning cooling equipment or a heat pump.

1. Air-conditioning and heat pump equipment used for cooling includes:
    a. Central air conditioning and heat pump split systems;
    b. Central air conditioning and heat pump packaged systems; and
    c. Wall-mounted, window, and portable air-conditioning and heat pump units.

10.4.1 Maintenance, Safety, and Efficiency Measures:

1. Maintenance, safety and efficiency measures will be performed on all existing and new air conditioning and heat pump appliances in order to maximize energy savings and the health and safety for the dwelling occupants. These measures are to be performed by trained and certified WAP personnel or contractors to ensure that the installation conforms to WAP standards. It will be the responsibility of the agency quality control inspector to ensure that these measures are in compliance with these Standards.
2. All maintenance, safety and efficiency measures performed must be documented in the client file.
3. Maintenance and efficiency measures will include:
    a. Visual inspection;
    b. Cleaning and tuning as necessary;
    c. Pre- and post-testing;
    d. Cleaning the fan, indoor and outdoor coils when necessary;
    e. Checking fan amp draw;
    f. Straightening damaged fins;
    g. Ensuring proper drainage of the coil(s);

h. Checking insulation condition on the suction line;
i. Checking equipment clearances for proper air flow around coils;
j. Duct sealing and insulation;
k. Checking for refrigerant leaks;
l. Verifying proper air flow with temperature drop and rise testing;
m. Checking and verifying correct refrigerant charge;
n. Cleaning and replacing filters; and
o. Air sealing and providing covers for permanent window and wall-mount air conditioners.

10.4.2 Replacement of Cooling Equipment

1. Window and wall mount air conditioners can only be replaced when justified with a Weatherization Assistant energy audit.
2. The replacement of an air -conditioning or heat pump unit is allowed only when:
   a. Every effort was made to repair and get the maximum efficiency and performance possible with the existing unit. Conditions required include:
      i. The unit cannot be cost effectively repaired or made to operate safely;
      ii. The replacement is well documented with sound justification in the client file;
      iii. Part of a package system and the heating portion cannot be cost effectively repaired or made to operate safely; and
      iv. Indoor coil is an integral part of the air handler.
   b. Air conditioning and heat pump equipment may be replaced with DOE/DHHR funds when justified by the Weatherization Assistant Audit (NEAT or MHEA). SIR justifications must be greater than one and cannot be done in lieu of mandatory priority-list measures. SIR replacement justifications must be documented with a Weatherization Assistant output report in the client file.
   c. Non-DOE funds may be used to replace an existing unit. Non-DOE funds are funds from other sources such as utility programs. However, this can be done only when the unit cannot be cost effectively repaired or made to operate safely and then only with GOEO approval and fully documented with sound justification in the client file. If replacements are done with utility program funds, they must comply with the program contract requirements.
3. Replacement of a heat pump unit is allowed when the following conditions exist:
   a. A Weatherization Assistant Audit (NEAT or MHEA) with an SIR greater than one has been completed.
   b. All mandatory priority measures have been addressed.
   c. Have documented sizing and design specifications, and is to be installed by trained and certified WAP personnel or contractors who comply with WAP Standards, code, and manufacturer's installation specifications.
   d. New replacement units must be ENERGY STAR rated and have an efficiency rating of at least:
      i. Central AC or Heat Pump Cooling Efficiency = 13 SEER
      ii. Heat Pump Heating Efficiency = 7.7 HSPF
      iii. Window and wall mount air conditioners = 10 EER

10.5 Subcontracting Heating System Work

Agencies who use contractors for any heating system replacement are responsible for verifying and documenting that the heating system needed replaced, was properly sized using Manual J, NEAT, or MHEA, that the installation complies with all national, state, and local codes, and that all West Virginia Weatherization heating system (including duct measures and standards) policies and procedures were followed. Agencies are responsible for ensuring that all mandatory health and safety testing pre- and post-weatherization documentation is in the client file.

Subcontractors will be responsible for any costs incurred due to a warranty or call back situation.

11 Heating/Cooling System Distribution

11.1 Ducted Distribution Requirements

Making the heating unit safe and efficient, while important, is only part of making the entire heating system as effective as possible. The condition of the delivery system will define the amount of heat that is actually delivered to the dwelling. A detailed inspection of supply and return ducts for air leaks or blockages must be made, and all problems corrected. Do not attempt to repair/seal ductwork on which asbestos is present.

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

11.1.1 Ductwork Inspection, Cleaning, and Sealing

4. Ductwork must be tested and sealed according to Section 6.11 on page 66.
5. Existing flex duct must be adequately supported without sags. Additional support is often needed.
6. Delivery and return ductwork must be cleaned as necessary to remove large objects and debris that may impede airflow through the heating system.
7. Uncover any blocked registers or grilles. Explain to the client the importance of maintaining the unrestricted airflow.
8. As necessary, supply registers and return air grilles must be removed and cleaned to remove excessive dirt and debris that may impede airflow. It may be necessary to use a cleaning solvent such as mineral spirits or denatured alcohol to eliminate any greasy buildup to ensure the duct sealing material will adhere properly.
9. When appropriate, remove and block off ducts, registers, and grilles located in unconditioned spaces.
10. Ductwork outside the thermal enclosure of the dwelling must be sealed with mastic and insulated.
11. All accessible return air ductwork within a combustion appliance zone (CAZ), except gravity systems, must be sealed enough to eliminate the potential for backdrafting.
12. Ducts and registers into non-living areas of the structure may be sealed off with the owner's permission as long as system efficiency is not compromised.
13. Existing crawl spaces used as plenums should be abandoned and replaced with a sealed duct system.

11.1.2 Duct Sealing

1. Gaps larger than ¼ inch between the air handler and adjoining ductwork or equipment will be bridged with sheet metal.
2. Other accessible duct joints, cracks, seams, holes, and penetrations will be sealed as specified below:
    a. Surfaces will be properly cleaned before sealing.
    b. Seams, cracks, holes, and penetrations less than ¼ inch will be sealed using fiberglass mesh and mastic.
    c. Seams, cracks, holes, and penetrations between ¼ and ¾ inch will be sealed in two stages:

i. They will be backed using temporary tape—duct tape—as a support prior to sealing;
ii. They will be sealed using fiberglass mesh and mastic. Fiberglass mesh and mastic will overlap the temporary tape by at least 1 inch on all sides.

d. Seams, cracks, holes, and penetrations larger than ¾ inch will be repaired using rigid duct material.
i. Fiberglass mesh and mastic will overlap the repair joint by at least 1 inch on all sides.

3. Installation of mastic will be applied in a manner that meets manufacturer specifications, as well as UL 181M, NFPA 90A and NFPA 90B.
4. In mobile homes, if the boot is loose to the floor, it will 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, fill the gaps with mastic or other appropriate materials. It may be necessary to use a cleaning solvent such as mineral spirits or denatured alcohol to eliminate any greasy buildup to ensure the duct sealing material will adhere properly.

11.1.3 Ductwork Sealing Materials

1. Cloth duct tape will never be used for duct sealing.
2. Existing duct tape must be removed before installing duct mastic or other approved sealing materials.
3. Mastic will meet the following requirements:
   a. Non-toxic and water-resistant.
   b. UL listed and labeled per UL 181A or 181B standards.
   c. Will be compatible with the duct material to which it is applied.
4. Fiber mesh tape used to reinforce duct mastic will 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.
2. For flexible ductwork:
   a. UL 181 BM listed tapes and mastic products will be used to seal the interior liner.
   b. All accessible joints, seams, and connections will be sealed with UL 181 approved mastics.
   c. Vapor barrier of all duct insulation will be taped to the flex duct using the taping system required by the manufacturer of the duct insulation.
5. Draw bands used to support or seal ductwork will meet the following requirements:
   a. Comply with the manufacturer's installation instructions.
   b. Use 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.
6. Ducts will be properly fastened and supported to prevent leakage:
   a. Metal-to-metal duct joints will be fastened with a minimum of three equally spaced screws.

b. Flexible-to-metal duct joints will be fastened with tie bands using a tie band tensioning tool.
c. Duct board is not an allowable material for new or replacement ductwork. However, the correction or repair of existing duct board is allowable.
d. Duct board to duct board joints will be fastened with a clinch stapler.
e. Duct board to flexible duct joints will be fastened with a metal take-off collar.
f. Metal plenum to air handler cabinet joint will be fastened with a minimum of three equally spaced sheet metal screws.
g. Flexible duct and duct board will be supported every 4 feet using at least a 1½-inch material.
    i. Support materials will be applied in manner that does not crimp the duct or reduce the interior dimensions of the duct.
h. Metal ducts will be supported by metal strapping, rods, or other standard materials.
i. Duct supports will conform to the duct manufacturer's installation instructions and must be corrosion resistant.

11.1.4 Ductwork Insulation

1. Active ductwork outside the thermal enclosure must be repaired if damaged, then sealed and insulated.
    a. Prior to installing insulation, ductwork must be sealed according to these Standards.
        i. 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 located within the thermal enclosure do not require thermal insulation.
    a. Exception: There might be cases where duct insulation is appropriate if within the thermal enclosure, 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 vents should not be insulated.
4. For ductwork that is not within the thermal enclosure of the dwelling, install a minimum of R-8 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, including checking for duct air tightness.
    b. Burying sealed ductwork in attic insulation is acceptable as long as the ductwork has an effective R-8.
5. Insulation must have a flame spread rating no greater than 25.
6. It is best to use vinyl-backed, reinforced foil duct wrap, or two-part foam on ducts.

7. The duct insulation should be installed with the vapor barrier on the outside, which will serve to cover the insulation. Any ductwork used for space cooling should have the vapor barrier taped at joints.
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 proper clearance between duct insulation and combustion appliance flues.
10. Install protective covering around the insulation where required by local regulations.
11. Ducts with existing asbestos insulation must not be disturbed.

11.1.5 New Ductwork Installations

1. New ductwork should not be installed unless absolutely necessary.
2. 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.
3. Attempt to install all new ductwork within the thermal/pressure enclosure.
4. Do not install ductwork within exterior walls.
5. Building frame cavities, closets, crawl spaces, and chases must not be used as ducts. However, ductwork may be housed by, or pass through these spaces.
6. Ductwork must be installed at least four inches from any bare earth.
7. Panned floor joists may not be used for air distribution.
8. A crawl space may not serve as a distribution plenum.
9. Do not use a dropped ceiling cavity as a plenum.
10. Flex duct can be used if more cost-effective to do so.
    a. Sections must be joined with a metal connection, mechanically fastened, and sealed at all joints.
    b. Flex duct must be supported according to manufacturer's specifications. Insulation mesh works very well for this purpose.
    c. Flexible ductwork must not be bent to more than a 45 degree angle without the use of a rigid elbow.

11.1.6 Duct Leakage in Site-Built Homes

1. West Virginia Weatherization requires combustion safety testing before and after weatherization to determine whether the furnace air handler significantly influences the pressure in the CAZ. To conduct this test, measure the pressure in the CAZ with reference to the outdoors with the furnace air handler off and then on.
    a. If the air handler significantly affects the pressure in the CAZ, call for the appropriate duct sealing on the job work order to mitigate the hazardous condition.
2. For ducts located in unconditioned spaces outside of the thermal/air enclosure:
    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 (zone pressure diagnostics) if

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

ii. Always repair disconnected ducts in the space.

b. If the unconditioned space is impossible to convert to a conditioned space or it is determined impractical to convert to a conditioned space:

i. Use a pressure pan to determine duct leakage to spaces outside of the thermal/pressure enclosure. Refer to Section 16.6.2 on page 146 for instructions on pressure pan use.

ii. Repair, seal with mastic, and thermally insulate ducts in unconditioned spaces to at least an R-8.

3. For ducts located in conditioned spaces (within the thermal/pressure enclosure), such as a basement or crawlspace:

a. Always repair disconnected ducts or ducts that are significantly leaking. Adhere to combustion safety testing recommended above in number 1 and 1.a.

b. Visually inspect the conditioned space to ensure that the shell is properly insulated.

c. If it is determined that weatherization work should be done to the shell of the conditioned space housing the ducts, perform a house-to-zone pressure and flow test (zone pressure diagnostics) if possible before and after the work to quantify the effectiveness of the work.

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.

e. Supply registers and return grilles may not be located in an attached or tuck-under garage.

f. All pre- and post-pressure testing must be documented in the Residential Audit Form.

11.1.7 Duct Leakage Standards for Mobile Homes and Double-Wides

1. If there is a belly return system in the mobile home or double-wide, convert it to a central return (living-space-system) (refer to Section 9.8 on page 93, Belly Return Conversions).
2. Inspect the duct work visually, and then seal all penetrations in the duct trunk line, boots, and seal the ends of the duct run.
3. When the above duct sealing work is completed conduct a pressure pan test on all duct registers including the furnace plenum.
4. If the furnace plenum is accessible, it must be sealed.
5. If the sum of the pressure pan readings is greater than 6 Pascals or an average of 0.7 Pascals per register, whichever is higher, the furnace plenum and branch ducts must also be accessed and sealed.

6. If the sum of the pressure pans readings is equal to or less than 6 Pascals or an average of 0.7 Pascals per register and all penetrations in the duct trunk line (boots, end of trunk line, visible penetrations) with the exception of the furnace plenum connection have been sealed, the task may be considered acceptable.
7. The ideal leakage is 0 Pa and 0 CFM leakage to the outside using the pressure pan. Technicians should strive to reduce all leakage as much if possible.
8. All pre- and post-weatherization pressure testing must be documented.
9. A duct blower may also be used to test the duct work. If this procedure is used, the task may be considered complete if the CFM leakage to the outside, measured at 25 Pa, is less that 10 percent of the total floor space. (Example; if a mobile home is 14 x 66, the area is 924 square feet. The Duct Blaster™ reading must be less than 10 percent of the floor area of 924, or 92.4 CFM).

11.2 Air Handler Pressure Balance Testing

11.2.1 Introduction

These test procedures are performed only in dwellings with central air handlers (furnaces and/or central air conditioners). Room-to-room pressure(s) should be measured in all rooms with forced air heating/cooling return or supply ducts and operable interior doors, after all weatherization work has been completed, but before the final combustion safety testing 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.

11.2.2 Whole House Test Procedure

1. Set up the house in winter operating mode.
2. Using a digital manometer, 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 is generally 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.

11.2.3 Room-to-Room Test Procedure

1. With a digital manometer 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.

11.3 Forced-Warm-Air Distribution Testing

The following tests will be done on distribution systems with air handlers and central ductwork.

11.3.1 Furnace Temperature Rise Measurement

This test is used to diagnose the operation of many parts of a ducted distribution system, including the air handler fan, duct leakage, cleanliness of the ductwork and fan, and other problems. See Section 16.4 on page 143 for the details of this test.

11.3.2 External Static Pressure Testing

This test helps determine problems with the ductwork and/or the distribution fan. See Section 16.5 on page 145 for the details of this test.

11.4 Piped Distribution Requirements

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

11.4.1 Steam and Hot Water Heat Distribution Pipes

1. Make certain there are no leaks in hot water or steam distribution pipes.

2. Supply and return lines in spaces outside of the thermal enclosure must be insulated if they are accessible.
3. Pipes may be insulated within the habitable space if it is determined that the space does not require heating or is overheated.
4. Pipe insulation must be sized to the pipe being insulated.
5. Pipe insulation must be rated for 160°F.
6. Secure the pipe insulation with mechanical fasteners or appropriate tape.
7. Pipe insulation must have mitered cuts at corner joints. Tape joints appropriately.
8. Pumps, valves, pressure relief devices, or vents should not be insulated. Do not insulate over heat tape.
9. Closed cell foam, high temperature rated insulation or elastomeric pipe insulation should be used that has a flame spread rating no greater than 25.
10. Maintain the manufacturer's recommended clearance between pipe insulation and combustion appliance flues.

12 Baseload Measures

The energy used by electric or gas appliances that is not related to space heating or cooling is called baseload energy. Usually the baseload use is consistent from month to month. Baseload energy includes lighting, refrigeration, water heating, cooking, washer and dryer, and electronics.

12.1 Storage Water Heaters

Based on a run of sample NEAT audits, the following standards apply to installation of water heater tank insulation.

1. Never insulate the water heater if it will void the manufacturer's warranty.
2. Insulate storage tanks that have existing insulation or less than R-11.

12.1.1 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 depressurization test procedures (see Section 16.7 on page 147).
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 120ºF 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 120ºF. 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.
7. Inspect the temperature/pressure relief valve to determine if it is installed correctly. If the temperature/pressure line is not installed to within 6 inches of the floor, install metal pipe, not plastic.
8. The pressure/relief pipe should be made of rigid metal pipe or approved high temperature plastic pipe.

12.1.2 Water Heater Insulation Materials

1. Hot water tanks must be insulated to a minimum of R-8. Water heater tank wraps must be fiberglass insulation with a vinyl backing, installed with the protective backing to the outside.
2. A water heater blanket must be secured to the water heater with at least two (2) vinyl straps (zip strips), and the insulation seams must be stitch stapled. The installed straps must not excessively compress the water heater blanket. Taping is not allowed as a sole fastening system.

12.1.3 Installation of Water Heater Insulation

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. Do not insulate a water heater if added insulation will void the manufacturer's warranty.
4. A water heater blanket must not be installed when a temperature and pressure relief valve does not exist or does not operate properly. If the water heater will accommodate a temperature and pressure relief valve and discharge line, install them and then insulate the water heater.
5. A electric water heater blanket must not cover the following:
   a. The pressure relief valve on an electric unit.
   b. The drain valve on an electric unit.
   c. Exception: The access panels to the controls can be covered but must be marked.
6. A gas water heater blanket must not cover the following:
   a. The top of the storage tank.
   b. The gas and temperature controls.
   c. Combustion air supply to the heater.
   d. Any opening between the tank and the floor.

12.1.4 Domestic Hot Water Temperature

1. Whenever feasible, the domestic hot water temperature must be measured and reduced to 120°F (measured at the faucet nearest the water heater) with the approval of the client/owner. If the client has a dishwasher without a water pre-heater, set the water temperature at 140°F.
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 and the new settings must be documented Residential Audit Form.

12.1.5 Domestic Hot Water Pipes

1. Make certain there are no leaks in domestic hot water pipes.
2. Insulate the first six feet of hot and cold water pipes closest to the water heater with pipe insulation.
3. Insulate all water pipes that are outside the thermal boundary.
4. Closed cell foam, high temperature rated insulation, or elastomeric pipe insulation should be used that has a flame spread rating no greater than 25.
5. Maintain a minimum of six inches between pipe insulation and all heat sources.
6. Pipe insulation must be sized to the pipe being insulated.
7. Secure the pipe insulation with mechanical fasteners or appropriate tape.
8. Pipe insulation must have mitered cuts at corner joints. Tape joints and seams appropriately with approved aluminum tape. Duct tape should not be used because its adhesive breaks down from the high temperature.

12.2 Water Heater Replacements

Water heaters can be replaced on a case-by-case basis under certain conditions. Replacement would rarely, if ever, be justified based on having a SIR greater than one; most replacements can be justified only because of health and safety concerns.

1. Replacement electric heaters must have an energy factor of at least 0.93. Replacement gas heaters must have an energy factor of at least 0.67.
   a. Replacement or repair is allowed where client health may be a concern.
2. An emergency drain pan will be installed a minimum of 4 inches above the floor. A ¾-inch drain line, or larger, will be connected to tapping on the drain pan and run to a drain or pumped to daylight.
3. A steel bladder expansion tank will be installed on the cold water side if required by local code.
4. Temperature/pressure relief value, dielectric unions, and backflow prevention will be installed according to the manufacturer's specifications.
5. The following will be checked once the new system has been filled and purged for:
   a. Safety controls.
   b. Combustion safety and efficiency.
   c. Operational controls.
   d. Fuel and water leaks.
   e. Local code requirements.
6. The occupants will be educated on the safe and efficient operation and maintenance of the new water heater, including:
   a. Adjustment of water heater temperature.
   b. Periodic drain and flush.
   c. Expansion tank and backflow preventer (no occupant maintenance required), if installed per local code.
7. Periodic inspection is recommended.
8. Replacements must be made according to manufacturers' specifications and applicable codes.

12.3 Flow Restriction Devices

12.3.1 Energy-Saving Showerheads

1. An energy-saving (low-flow) showerhead should be installed with client permission, if the existing showerhead flow is measured at greater than three gallons per minute (gpm)—or one gallon in 20 seconds—and the installation does not require the services of a plumber.
2. The energy-saving showerhead must have a flow rating of 2.0 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 energy-saving showerhead.
4. Removed showerheads may be left with the client at their request.
5. The occupant's acceptance of a showerhead should be documented.

12.3.2 Faucet Aerators

1. Measure aerator flow rate. Replace if rate is higher than 1.2 GPM.
2. Removed aerators may be left with the client at their request.
3. The occupant's acceptance of an aerator should be documented.

12.4 Gas-Fired Cooking Ranges

Gas ranges will be inspected, tested, and appropriate client education will be delivered to an adult client in the household.

12.4.1 Inspection, Testing and Adjustment of Gas-Fired Ranges

1. Check for CO in ambient air upon arrival. If greater than 9 ppm, determine the source and correct the problem before proceeding.
2. Inspect the gas range installation for code compliance. Refer to the latest edition of the National Fuel Gas Code (NFPA 54) under Household Cooking Appliances.
3. Check for gas leaks. If leaks are found, repair and document them before proceeding.
4. Check the flexible range connector for the date ring. If the connector doesn't have a date ring and/or is brass, replace the connector. The connector must connect outside of the cabinet and must pass through the wall of the range cabinet.
5. For the range top burners (no testing required):
    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.
6. For the oven bake burner (do not test a separate broil burner):
    a. Remove cooking utensils from oven. Make sure foil or other materials are not obstructing the holes in the oven floor.
    b. Turn on burner to the maximum temperature, but not to "broil."

c. Insert the probe into the oven vent far enough to get an undiluted exhaust gas sample.
d. The CO emissions increase and then peak just after burner starts up; they then fall to a momentary plateau before the burner shuts down as part of the duty cycle. The reading CO ppm must be taken during this momentary plateau. Record this "plateau" reading in the Residential Audit Tool.
e. If the reading is above 800 ppm air-free, then:
   i. Clean any rust and soot buildup on the spreader plate caused by flame impingement. It may be necessary to install spacers to raise the flame plate out of the flame. Educate the client on how to clean the flame plate.
   ii. Clean the burner if needed.
   iii. Check for obstructed secondary air. If it is obstructed, remove the obstruction and educate the client on how to keep from obstructing the burner.
   iv. Check the primary air adjustment and adjust if necessary or clear away any restrictions.
   v. Check to see that the burner is in alignment; it may require leveling the entire appliance.
   vi. Check the orifice size to ensure they are the right type and size in regard to LPG or natural gas. If the orifices need to be changed or adjusted, do so with the burner and the pilot orifices.
   vii. With a manometer (water column gauge) check that the gas pressure is correct. If the pressure regulator requires replacement, do so.

12.5 Refrigerator Replacement and Metering

The refrigerator to be replaced must be the primary refrigerator used by the household. In cases where more than one refrigerator or freezer is being used, the agency should encourage the client to dispose of the secondary refrigerator or freezer by providing client education regarding the energy use of the unit(s). The disposal of a secondary refrigerator or freezer is an eligible activity. The preferred method for evaluating energy usage is measuring the consumption with a "plug load" meter.

12.5.1 Refrigerator Replacement Policy

1. Refrigerator replacements must meet DOE requirements.
2. When utilizing DOE/DHHR funds the replacement refrigerator must be cost-effective.
3. Criteria for replacement:
   a. If the savings-to-investment ratio is greater than one but less than two, the agency has the option to replace it or not.
   b. If the savings-to-investment ratio is greater than two, then the refrigerator must be replaced. The savings-to-investment ratio must be documented in the client file. Agencies may combine electrical usage for the purpose of calculating cost-effectiveness when more than one refrigerator or freezer is disposed as part of the refrigerator replacement.
4. Utility funds can be used for a refrigerator replacement, whether the home is electrically heated or not. The savings-to-investment ration must be 1.5 or greater to use these utility funds for the refrigerator replacement.
5. The client must give up possession of the old refrigerator.

6. The NEAT audit tool must be used to calculate savings-to-investment ratio (SIR) and to provide documentation that the replacement SIR is greater than one. NEAT can calculate the SIR of a refrigerator replacement in two ways:
   a. Built in Association of Home Appliance Manufacturers (AHAM) database of refrigerators.
   b. With the use of on-site metering data in units of kWh.
7. Age alone should not be the determining factor in replacing a refrigerator. Although older refrigerators were built to less efficient standards, other factors such as size and manual defrost impact energy use of existing refrigerators. However, any refrigerator older than 1993 may be a likely candidate for replacement. A refrigerator 10 years or older must be analyzed and considered for replacement, either by obtaining the information from the AHAM databases or by on-site metering. SIR justifications must be recorded on the refrigerator replacement form and in Facs Pro electronic data management.
8. The agency will complete a Refrigerator Inspection and Replacement Form and make it part of the client file. The information entered on this form will include, but not be limited to:
   a. Exact replaced refrigerator model number, not a shortened or abbreviated number.
   b. SIR value calculated with NEAT.
   c. If refrigerator is metered, the kWh—not watt hour—and meter run time.
8. Refrigerators should be tested by the auditor and findings recorded in the Residential Audit Tool.
9. The agency will ensure that the refrigerator is installed prior to reporting the job as completed when DOE/DHHR or ARRA funds are utilized. Utility funds can be added on at a later date if refrigerator delivery is delayed and the job is designated as a utility job in Facs Pro prior to installation.

12.5.2 Refrigerator Metering

1. An energy "plug load" meter must be connected to the refrigerator(s) for at least two hours. The longer the metering time, the more accurate the projected annual kWh/yr. estimate will be. For auto-defrost refrigerators, the analyst must always be aware of whether the refrigerator defrost mode is activated or not during the metering period. It is strongly recommended to conduct a 24-hour test whenever possible. A 24-hour test will be more accurate by including automatic defrost cycles and typical daily household use of the refrigerator.
2. Determine the average ambient temperature around the refrigerator during the metering and enter in the NEAT software.
3. Convert the "WATT HOUR" reading on the plug load meter to kilowatt hours (kWh) by dividing the WATT HOUR reading by 1000. Enter the resulting value in the appropriate place in the NEAT software. For example, if the WATT HOUR reading on the plug load meter is 525, the kWh value entered in the NEAT software is 525/1000, or 0.525.
4. Enter the time period of the metering in the NEAT software. Make sure the time is in units of minutes.

12.5.3 Ordering Replacement Refrigerators

1. The replacement should be of a similar style and capacity as the removed refrigerator. A larger capacity model than the removed unit may be considered if multiple refrigerators/freezers are being replaced.
2. If the existing refrigerator has an ice maker, replacement can be ordered with ice makers, if all criteria are met. An existing water connection must already be available for shipper to reconnect. If the replacement has a factory-installed ice maker, and client has no water connection, it will be the client's responsibility to have connected. Neither WAP grant funds nor utility funds can be used to run water line for an ice maker.
3. Each agency is responsible for ordering refrigerators and for payment. Ordering will be done using the supplier's on-line ordering system. Supplier will invoice each agency separately.

12.5.4 Installation of New Replacement Refrigerator

1. The agency must ensure that the correct unit is being ordered. The replacement must fit into the existing refrigerator space and must have the hinges installed on the appropriate side. There will be a fee charged to the agency if hinges need to be realigned at the client's home. The agency should also insure that a replacement is practical in that there is safe and adequate electrical supply, the floor is structurally adequate to properly support the new unit, and the doors and hallways of the home are sufficient to allow removal of the old refrigerator and installation of the new one.
2. The agency must stress that the client must be home at the time of the delivery. There will be a fee charged if no one is home at the agreed delivery time. In this instance, the agency will have to invoice the client and remit the fee to the supplier.
3. A shipping company will deliver the replacement, install the unit, remove, and properly dispose of the old unit(s). They will also remove all packing from the client's premises.
4. The shipping company will arrange delivery date and time with the client. The shipping company will fax delivery dates and times to the agency, if requested. The shipper will be required to remove the old refrigerator and dispose of properly.

12.6 Compact Fluorescent Bulbs

12.6.1 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.

Manufacturers producing ENERGY STAR qualified CFLs are required to offer at least a two-year limited warranty (covering manufacturer defects) for CFLs used at home.

12.6.2 Replacement Procedure

1. All replacement CFLs must be ENERGY STAR® rated.

2. Discuss the lighting schedule with the client. Focus on incandescent lamps that are on for one or more hours each day.
   a. Educate the client about incandescent lamp use, including using these lamps as little as possible
   b. Ask the client, after your client education efforts, which incandescent lamps are likely to be on for one or more hours each day. Replace these incandescent lamps with compact fluorescent lamps (CFLs).
3. Any replacement CFLs should have a lumen rating (light output) very close to the replaced incandescent lamp. Generally, a CFL will have one-third the wattage of an incandescent with comparable lumen output.
4. Replacement CFLs should be rated 2700 to 3000 Kelvin. This color index is similar to incandescent bulbs.
5. EPA recommends that consumers take advantage of available local recycling options for compact fluorescent light bulbs. EPA is working with CFL manufacturers and major U.S. retailers to expand recycling and disposal options. Consumers can contact their local municipal solid waste agency directly, or go to www.epa.gov/cfl/cflrecycling.html or www.earth911.org to identify local recycling options.

13 Multifamily Building Weatherization

For energy auditing purposes, DOE considers multifamily buildings to be those containing five dwelling units or more. The NEAT energy audit or the Priority List for site-built and multifamily structures may be used in buildings with one to four dwelling units. The NEAT audit may be used on some multifamily buildings up to 25 *individually* heated/cooled dwelling units.

For small multifamily buildings with 25 or fewer dwelling units, 3 stories or less, that are individually heated and/or cooled, NEAT must be used.

West Virginia does not currently weatherize units that are greater than 3 stories which are centrally heated, or are larger than 25 units per building. As training becomes available these larger multifamily buildings may be addressed at a later date.

Multifamily structures will require a landlord contribution, unless the landlord qualifies for low-income weatherization and a signed contract by the owner or authorized agent.

Lead safe work practices on qualifying buildings are to be performed by documented EPA Certified Renovators and in full accordance with the EPA work practice standards, On HUD housings projects, the owner must provide a Certificate of Lead-Based Paint Compliance prior to the start of any weatherization work. Refer to Section 4.14 on page 40.

All undertakings that involve properties older than forty-five years are subject to review under Section 106 of the National Historic Preservation Act. Historic Preservation Review protocol documents must be submitted to the GOEO weatherization specialist for review and approval prior to any federal funds being spent on a structure.

For further guidance refer to the state Multiple Dwelling Unit Guidance document.

All weatherization measures must have a savings-to-investment ratio of 1 or greater.

Table 13.1
Multifamily Dwelling Units (MDU) Types and Required Audit Tools

Multifamily Dwelling Unit (MDU) Type	Required Audit Tool
1-5 units that are individually heated or cooled, garden style apartments	Priority list or NEAT audit with 3 or less stories
Small MDU less than 25 units where units are individually heated or cooled	NEAT audit sampling*

*Audit Sampling: To ensure a true representation of the building, an audit(s) must be completed on apartments with different configurations and heat loss characteristics (for example, 1 bed. bottom floor, 1 bed. middle floor, 1 bed. top floor, 2 bed. bottom floor). An audit of at least 25 percent of the total number of units in each building must be conducted. Each audit must include photo documentation of existing conditions (for example, insulation levels, venting, etc.).

13.1 Multifamily Building Differences

The energy-saving options in for small multifamily buildings are similar to those for single-family buildings. However, larger multifamily buildings require a different approach and the energy-saving options differ. Rather than an energy auditor performing the inspection and deciding on the measures, larger multifamily buildings are often inspected by a team of experts, including the energy auditor. Additionally, procedural details must be worked out at the beginning of a project, such as:

1. Who is the client, the tenant or the owner?
2. Who must apply for weatherization services?
3. Who pays for the utilities, the owner or the tenant?
4. Is there a building manager?
5. Who will decide what measures are implemented?

Some of the possible energy-saving options for larger multifamily buildings include:

1. The heating systems usually are boilers and serve many units.
    a. Balancing and insulating distribution.
    b. System controls, such as outdoor reset, in-unit temperature controls, and cycle control.
    c. Install modular system.
2. Domestic hot water systems.
    a. Water temperature.
    b. Install low-flow showerheads and faucet aerators.
    c. Insulate distribution pipes.
    d. Separate domestic hot water from space heating.
    e. Install storage tanks for tankless coils.
3. Enclosure treatment.
    a. Air seal and insulate attic.
    b. Often difficult to insulate walls if masonry.
    c. Repair broken glass, seal holes in walls, and re-point masonry.
    d. Treat air conditioner sleeves.
    e. Reduce stack effect within building by sealing vertical shafts and chases.
    f. Ensure that all wall elevation offsets are addressed to correctly define the thermal boundary.
4. Mechanical ventilation should be analyzed for effectiveness and savings.
    a. Follow ASHRAE 62.2-2010 standard.
    b. Does the system work? Are the units and common areas over or under ventilated? Do the controls work?
    c. Clean and balance system(s).
    d. Measure flow rates.
5. Baseload
    a. Replace refrigerators if justified by resulting SIR.
    b. Evaluate interior lighting.

14 Agency Final Inspection Procedures

The Department of Energy and West Virginia GOEO require that final inspections be performed to assess adequacy and quality of work. The DOE regulation reads as follows:

"No dwelling unit may be reported to DOE (or West Virginia GOEO) as completed until all weatherization materials have been installed and the agency (the CAA) or its authorized representative, has performed a final inspection(s) including any mechanical work performed and certified that the work has been completed in a workmanlike manner and in accordance with the priority determined by the audit procedures required by 440.21."[7]

Final inspections must be performed by certified quality control inspectors who did not perform the initial audit or other work on the job. Inspectors who have not been certified cannot perform a final inspection without the accompaniment of a State monitor or certified inspector. Any exceptions to this policy must have approval from GOEO Weatherization Director.

14.1 General Requirements

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

1. All weatherized units must be reported to GOEO as completed only after the agency has performed a final inspection. The purpose of the final inspection is to ensure that the work has been completed in a workmanlike manner and in accordance with the priority lists or the NEAT or MHEA energy audits and work order.
2. Agencies are required to inspect 100 percent of installed measures.
3. The certified inspector will assess the job to ensure that the crew or contractor has not damaged any existing finishes and items in the home.
4. The certified inspector must also ensure that the contractor or crew have left the dwelling in a clean and orderly manner, both inside and outside.
5. The Post-Work Inspection Form must be followed at all times during the final inspection and any items that have not been completed to the satisfaction of the quality control inspector must be noted on the Corrective Action Work Order. The quality control inspector must re-inspect any work corrections to ensure completion and quality of work. The quality control inspector must sign the form to attest that the job is completed according to the Corrective Action Work Order.
6. The inspector is responsible for obtaining all the proper homeowner signatures on the final sign-off for the project.
7. The final inspection must verify that the materials were installed and confirm that they were installed in a professional manner in accordance with the West Virginia Weatherization Field Standards and Best Practices.
8. The quality control Inspector must ensure that a weatherization tags are installed. The certified inspector must initial the weatherization tag, with a permanent magic marker and install a clear plastic protective cover over the tag. The quality control inspector will verify that the DBA Facs Pro tag number matches the job book number and that photo documentation of tag installation is in client file.

[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).(g).

a. Tags must be placed in two locations on a dwelling:
    i. On the inside cover of the electrical panel/box or other place on the panel if the cover is missing; or
    ii. For site-built homes: on an attic rafter or beam within sight of the attic hatch.
    iii. For mobile homes: on the frame of the mobile home where the waterline enters the dwelling.

9. The quality control Inspection Form must be signed by the crew supervisor and quality control inspector verifying that all work conforms to the West Virginia Field Standards and Best Practices.
10. Cited deficiencies noted in the State monitoring report that result in a call back or rework are considered justification for requiring re-inspection of a dwelling.
11. Client or scheduling obstructions to final inspection:
    b. GOEO recognizes that in some cases it may be impossible to complete a final inspection of the dwelling unit, even after repeated efforts to schedule the inspection. In these cases, the agency must document that an inspector made a significant effort to inspect the dwelling after completion of the weatherization work. At a minimum, a visual inspection of any exterior weatherization measures must be completed.
    c. A memorandum must be put in the client file, signed by the inspector and the agency weatherization coordinator, indicating the dates when the agency attempted to inspect the residence.
        i. The agency will also be required to make every effort to obtain required signatures and to thoroughly document all work performed on all completions,
        ii. If the client does not respond within two weeks, the agency may report the unit as a completion. In this situation, a second memorandum, signed by the inspector and weatherization coordinator and placed in the client file, should indicate that the agency was unable to conduct a final inspection.
12. The final inspection of a unit, at a minimum, will include:
    a. Verification that all materials reported on Facs Pro is present or can be physically accounted for on the Residential Audit Tool during the on-site inspection by the quality control inspector.
    b. Materials were installed in such a way as to be safe, effective, and neat in appearance.
    c. Confirmation that all materials used on the home meet required West Virginia Weatherization Field Standards and Best Practices.
    d. Verification that all combustion systems are in safe operating condition and that all safety tests were performed and documented.
    e. Documentation that any problems found during the inspection were resolved in an appropriate and timely manner.
    f. Verification that all LSW practices were documented with photos and that "Renovate Right: Important Lead Hazard Information for Families, Child Care Providers and Schools" was distributed properly and signed with appropriate documentation in the client file.

13. Confirmation that all required documentation is signed (where needed) and in the client file must be noted on the Post-Work Inspection Form. Refer to Section 1.10.1 on page 5 for required job documentation.

14.2 Inspection of Wall Insulation

1. Refer to Section 7.2 on page 76 for the details of wall insulation.
2. Verify that the sidewall insulation has been installed in all required wall cavities.
3. 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.
4. Any replaced wood siding or trim must match the existing grade and be primed or sealed with an appropriate paint or stain.
5. Verify that blown insulation has not deformed or damaged the interior wall surfaces.
6. If the insulation was blown into the wall cavities from the inside, make sure that:
    a. The interior fill holes have been covered with a chair rail.
    b. Verify that no insulation or debris is left in the house.
    c. Verify that insulation has not escaped into wall heaters, vent fans, ducts, or other mechanical penetrations.
    d. Make sure that structural details such as interior soffits, pocket doors, and other bypasses have been properly addressed during the insulation installation.
7. 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.
8. If the finished siding has been face-drilled and plugged, make sure that the reasons for doing so are included in the client file.
9. Verify that cellulose insulation has been installed at the proper density.
    a. Cellulose should be installed at a high density in walls whenever conditions. High density is at least 3.5 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.

14.3 Inspection of Attic Insulation

1. Refer to Section 7.1 on page 69 for the details of attic insulation.
2. 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.
3. Verify that all voids and areas of incomplete coverage in the existing insulation have been repaired.
4. 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 marking.
   f. Bathroom and kitchen exhaust fan ventilation.
   g. Knob-and-tube wiring.
5. Zone Pressure Diagnostics (ZPD) is a required tool for determining the pre- and post-tightness levels of attic pressure boundaries. Please refer to Section 16.8 on page 152 for details.
6. 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.
7. Verify that attic venting is added as specified in the Work Order. Attic venting must not be blocked with installed insulation.
8. Verify that Insulation Certification is completed and posted inside the attic access and is clearly visible to the client.

14.4 Inspection of Attic Access and Knee Wall

1. Make sure the attic hatch is at least accessible and at least 20 inches in width or length, weatherstripped, latched, and insulated with at least four inches of extruded polystyrene (R-20) that is properly secured to the exterior surface of the attic hatch. Two-part foam is not an acceptable material for insulating hatches.
2. Verify that pull-down stairs are properly insulated and weatherstripped.
3. Make sure all knee wall areas have access doors and are properly insulated, weatherstripped, and latched. See Section 7.1.4 on page 71.

14.5 Inspection of Basement and Crawl Space Insulation

1. Refer to Section 7.3 on page 80 for the details of basement and crawls space insulation.
2. Verify that the treatment of a basement or crawl space corresponds with the appropriate definition of the thermal boundaries of the dwelling.
3. Make sure that all foundation air sealing has been completed.
4. Verify that allowable repairs have been made to correct any moisture or sewage problems.
5. Verify that all insulation installation required by the Work Order has been properly installed.
6. Verify that an appropriate ground cover has been installed in crawl spaces, when possible.
7. Verify that water lines have been appropriately insulated, if necessary.
8. Verify that damaged or missing exterior doors have been repaired or replaced and that they are weatherstripped and insulated according to the Work Order.

14.6 Inspection of Dryer Vent

1. Verify that the dryer is properly vented to the outdoors and that the damper in the dryer vent is working properly.
2. Verify that dryer vents are extended to the outdoors without sags or in such a way as to allow the pooling of condensate.
3. Verify that the dryer vent is installed according to Section 4.15.3 on page 45.

14.7 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 4.16 on page 45.
3. Make sure the client knows how to properly use all newly installed exhaust fans.
4. Verify that the exhaust fans are working properly. Measure the actual exhaust fan CFM airflow rate with an appropriate instrument.

14.8 Inspection of Whole-Building Ventilation Fans

1. Verify that all 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 whole-building fan flow rates, controls, and installation comply with Section 4.16 on page 45.

14.9 Inspection of Baseload Measures

1. Refer to Chapter 12 on page 119 for the details of baseload measures.
2. Verify that any work specified for the water heater has been completed according to the Work Order and all work complies with the specifications of this Standard and applicable codes.
3. If a replacement refrigerator has been specified in the Work Order, verify that the new refrigerator is in place and working properly. Verify that the replaced refrigerator(s) have been removed from the site.
4. If the work order specified replacement of incandescent bulbs with compact fluorescent lamps (CFLs), verify that the CFLs are in place and working properly.
5. Verify if low-flow showerheads were specified in the Work Order and installed.

14.10 Inspection of Heating and Cooling Systems

Verify that any work specified for central heating systems, space heaters, central cooling systems, window air conditioners, heat pumps, and corresponding distribution has been completed according to the work order and all work complies with the specifications of this Standard and applicable codes. Refer to Chapter 10 on page 99 and Chapter 11 on page 111 for details of conditioning systems and distribution systems. Inspection must include verification of combustion safety testing. Refer to Section 16.7 on page 147 for details.

14.11 Documentation in Client File

1. Central Customer Report with signed disclaimer which includes homeowner's permission to work on the dwelling and fuel bill release authorization.

2. Income Verification with client's statement of income, back-up documentation, and re-verification, when necessary. Refer to WPN 10-1 or WPN 10-18 for further guidance on definition of income.
3. Owner Agreement Form for rental unit (if applicable).
4. Residential Audit Tool/Work Order detailing all aspects of the job concerning the actual weatherization of the home, including the job orders, actual material used and cost, and a home inspection. This document must be signed by the auditor and crew supervisor.
5. Confirmation of Receipt of Lead Pamphlet (if applicable) certifying that the EPA booklet "Renovate Right: Important Lead Hazard Information for Families, Child Care Providers and Schools" was given to the client prior to the start of work in homes built before 1978. Clients must receive this booklet at least seven days before work begins if physically delivered. If mailed, Pamphlet must be mailed fourteen days before work starts.
6. The Energy Saver's Partnership Plan and Energy Education Certification Form documenting the energy education provided by the agency to the client.
7. Mold and Moisture Assessment Findings Form to assess existing moisture and/or mold problems in the dwelling.
8. Hold Harmless Statement (if applicable) to document existing or potential health and safety problems that the Weatherization Assistance Program will not be able to repair.
9. Carbon Monoxide Warning Statement (if applicable) to document high levels of carbon monoxide found when testing combustion appliances.
10. Solid Fuel Inspection Report for each solid fuel appliance.
11. Photos to document any health and safety concerns, pre-work and post-work photos of when window(s) or door(s) are replaced, Lead safe work site and postwork inspector verification of Insulation and air sealing of closed knee walls. For the details of lead safe work practices, refer to Section 4.14 on page 40.
12. A signed quality control inspection report indicating that all work has been performed in accordance with the West Virginia Weatherization Field Standards and Best Practices, all safety tests have been correctly documented and all required documentation is in client file. This report must be part of the client file and signed by auditor and crew supervisor.
13. Copy of Historic Preservation documents to include WAP Undertakings Exempt from Historic Preservation Section 106 Review and WV WAP Historic Preservation Review Sheet, if applicable.
14. Daily Combustion Safety testing form.
15. Documentation of justified deviation from Work Order (if applicable).
16. As GOEO moves forward, the WAP electronic management system will be utilized as a substitute for some current written documentation. GOEO will provide the necessary guidance as the WAP electronic management system is developed.
17. A completed written Job Book. An electronic management system copy may be requested by GOEO monitors on site, and/or utilized for desktop monitoring purposes.

Note: The paper application form and income verification form are not needed if the client is in the agency electronic information management system. All required information must still be complete.

15 Field Monitoring Procedures

Monitoring will take place while the program is in operation and provide oversight for the services being delivered at the local level. Monitoring activities ensure that accountability exists for program resources and provides information that can be used to improve the program's operation and services.

Agencies will be monitored as required by DOE, refer to GOEO Universal Monitoring Procedures and the Program Field and Fiscal Monitoring Procedures for guidance.

15.1 Job Rework Guidelines

Any completed jobs that were deemed as "call-backs" during a grantee monitoring visit shall be corrected according to the instructions from the Field Inspection Reports. The agency must maintain documentation of the additional measures performed and, unless the mandated DOE regulation for additional work is followed, no federal funds may be used to cover any additional costs. Documentation must be in either the Client File or in the WAP electronic information management system.

As a general rule, GOEO and agencies may not charge the WAP for additional work on homes that have already been reported to DOE as completed weatherized units. Once a home is reported to DOE as completed, the required final inspection indicates that all applicable work performed was done in a workmanlike manner, including all work that may have been contracted out, such as furnace work. Performing activities such as routine maintenance, repairs, or warranty-type work is not permitted using DOE funds for work beyond those costs already invoiced. GOEO and agencies may use other funds that are not included as a part of their DOE WAP budget plans to pay for the costs associated with these activities.

The only way to address call-backs where DOE funds are used to pay for the additional work is to have costs for these previously completed units taken out of the DOE reporting system and to subtract the associated costs from the DOE funds category. The Project Officer must be notified in writing of the number of units, total costs, and reporting period (monthly and/or quarterly) for any units that are to be backed out of the PAGE system. The Project Officer must then reject the report so that the revised reporting adjustments can be made. Further, grantees must coordinate with their financial office to ensure the appropriate accounting methods follow Federal cash management procedures.

After making any necessary repairs, the agency must re-inspect the unit and report the completion to the grantee who will then report the unit to DOE, including all final costs for the unit in the month the completed work takes place. In considering this option, it should be noted that this process is time-consuming and should be utilized only on a limited case-by-case basis. Any proposed exception to this guidance must be provided by the agency to the grantee and submitted to DOE for approval. Agencies that primarily use contractors are likely not to have this issue. The contracts for HVAC or other work using DOE funds must ensure that adequate guarantees of workmanship, implied or otherwise, are part of the bid process. These costs are generally built into to the contract, including the equipment, workmanship, and the length of time covered by any implied warranty required in the bid specifications. This program notice affects all units weatherized after January 10, 2011 with any-year's appropriated funds as well as Recovery Act funds.

Refer to WPN 11-03 for more information.

15.2 Agency Discipline Policy

The Governor's Office of Economic Opportunity may, by giving written notice specifying the effective date, terminate or suspend this agreement in whole or in part for cause, which will include:

1. Failure, for any reason, of the agency to fulfill in a timely and proper manner its obligations under this agreement, including compliance with the approved program and attached conditions, with statutes and Executive Orders, and with such federal directives as may become generally applicable at any time;
2. Submission by the agency to the federal funder or to the Governor's Office of Economic Opportunity of reports that are incorrect or incomplete in any material respect;
3. Ineffective or improper use of funds or equipment, either direct or indirect, provided under this agreement;
4. Program irregularities of the agency as determined by the Governor's Office of Economic Opportunity;
5. Suspension or termination by the federal funder of the grant under which this agreement is made, or the portion thereof delegated by this agreement; or
6. Failure to cooperate with the requirements of the audit or other reasonable requests made by the Governor's Office of Economic Opportunity.

The Governor's Office of Economic Opportunity may also assign and transfer this agreement to another agency or other qualified entity when necessary or when required to do so by the direction of the federal funder. Any suspension or termination of this agreement must be by written notice setting forth the effective date of the same.

If the agency is unable or unwilling to comply with such additional conditions as may be lawfully applied by the federal funder to the grant and to the Governor's Office of Economic Opportunity, the agency will terminate the agreement by giving reasonable written notice to the Governor's Office of Economic Opportunity, signifying the effective date thereof. In such event, the Governor's Office of Economic Opportunity may require the agency to ensure that adequate arrangements have been made for the transfer of the delegated activities to another agency, another qualified entity or to the Governor's Office of Economic Opportunity.

This is from OMB Circular A 110: The Governor's Office of Economic Opportunity may also place special award conditions if an applicant or recipient:

1. Has a history of poor performance,
2. Is not financially stable,
3. Has a management system that does not meet the standards prescribed in OMB Circular a 110,
4. Has not conformed to the terms and conditions of a previous award, or
5. Is not otherwise responsible.

The Governor's Office of Economic Opportunity may also impose additional requirements as needed, provided that such applicant or recipient is notified in writing as to: the nature of the additional requirements, the reason why the additional requirements are being imposed, the nature

of the corrective action needed, the time allowed for completing the corrective actions and the method for requesting reconsideration of the additional requirements imposed. Any special conditions will be promptly removed once the conditions that prompted them have been corrected.

16 Diagnostic Testing Procedures

16.1 Blower Door Testing

The use of a blower door as a weatherization tool is mandatory. It must 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 West Virginia Weatherization Program 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 are generalized to include the equipment sold by the Energy Conservatory and Retrotec. Please refer to the manufacturer's instructions for more detailed information.

16.1.1 Preparation for Blower Door Test

1. Agencies and contractors should maintain accurate calibration of their blower doors and related equipment. This includes:
    a. Blower door fan.
        i. There should be no physical damage to the fan.
        ii. The flow sensor is one of the most critical parts of the blower door fan. Make sure the sensor is in its proper position, not damaged, that the connected hose is in good condition, and that the holes in the sensor are not blocked.
    b. If there is a problem with the fan or the flow sensor, contact the manufacturer before further use.
    c. Digital pressure gauges must be calibrated as recommended by the manufacturer.
    d. For detailed maintenance recommendations check with the equipment manufacturer.
2. Deactivate all vented combustion appliances before depressurizing the structure by turning the thermostat down, or by shutting the appliance off. A gas water heater may be set on "Pilot" rather than setting the control on "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 primary windows, self-storing storm windows (if possible), skylights, and exterior doors and latch them in the position they normally would be found during the winter.
6. Open all livable areas to the interior of the structure, even if the occupants close them off during the winter.

7. If the basement is defined as an area within the thermal enclosure, determine the CFM_{50} value with the blower door 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.

16.1.2 Blower Door Test, Depressurization (typical)

1. Set up the blower door in an exterior door that has the least number of obstacles within 3 feet of the blower door fan. If the doorway leads to an enclosed area, make sure the space is open to the outdoors. Do not set up in a door facing the wind if an acceptable alternative exists.
2. Install the frame and panel securely into the doorframe, making sure there are no gaps between any of the components or between the components and the doorframe.
3. Set the fan into the panel/frame assembly, making sure that the panel opening fits snugly around the fan. Install the fan so that the flow ring assembly (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 digital manometer 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. Attach the hoses properly to the digital gauge and blower door.
7. Inspect building for structural integrity and health and safety concerns that could be affected by the depressurization test.
8. 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 too low (your digital manometer will indicate if the fan is running too slowly to reach a proper fan pressure). If wind seems to be affecting the test results, take several one-point tests and average the results.
9. Determine the CFM_{50} value with the digital manometer.

16.1.3 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 valid reason.
   a. Generally a pressurization test is not done because it is more difficult, primarily because the flow rings/range plates must be positioned on the outdoors.
2. Install the door panel as it is normally.
3. 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.
4. Level and stabilize the fan as necessary.
5. Do not change the fan directional switch from its normal (forward) position.
6. Attach the hoses properly to the digital gauge and blower door.
7. Perform a one-point test by pressurizing 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 too low (your digital manometer will indicate if the fan is running too slowly to reach a proper fan pressure). If wind seems to be affecting the test results, take several one-point tests and average the results.

8. Determine the CFM_{50} value with the digital manometer.

16.2 Air Leakage Reduction Standards

West Virginia GOEO recognizes that cost-effective air sealing is extremely important. Please refer to Section 6.2 on page 60 for the details of air leakage reduction.

16.3 Depressurization Tightness Limit (DTL)

16.3.1 Introduction

If the dwelling has any gas-fired Category I, Category I fan-assisted, Category III, or Category IV non-direct vent or oil-fired appliance combustion appliances, the Depressurization Tightness Limit (DTL) should be calculated before weatherization work begins.

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

If the energy auditor expects exhaust fans will be added to the dwelling in order to comply with ASHRAE 62.2-2010, an estimate of the CFM fan flow of these added fans should be included in this procedure.

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

16.3.2 DTL Procedure

1. Use Chart 16.1 to find the DTL CFM_{50} value.
    a. Determine the Total CFM of Exhaust Ventilation and Appliances in the dwelling. It is always better to measure the exhaust fan flow, if possible, rather than estimate the fan flow. Include any appliances that are not yet installed, but will be during your weatherization work. For example, include the CFM exhaust fan flow 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 16.3 for guidance.

Chart 16.1

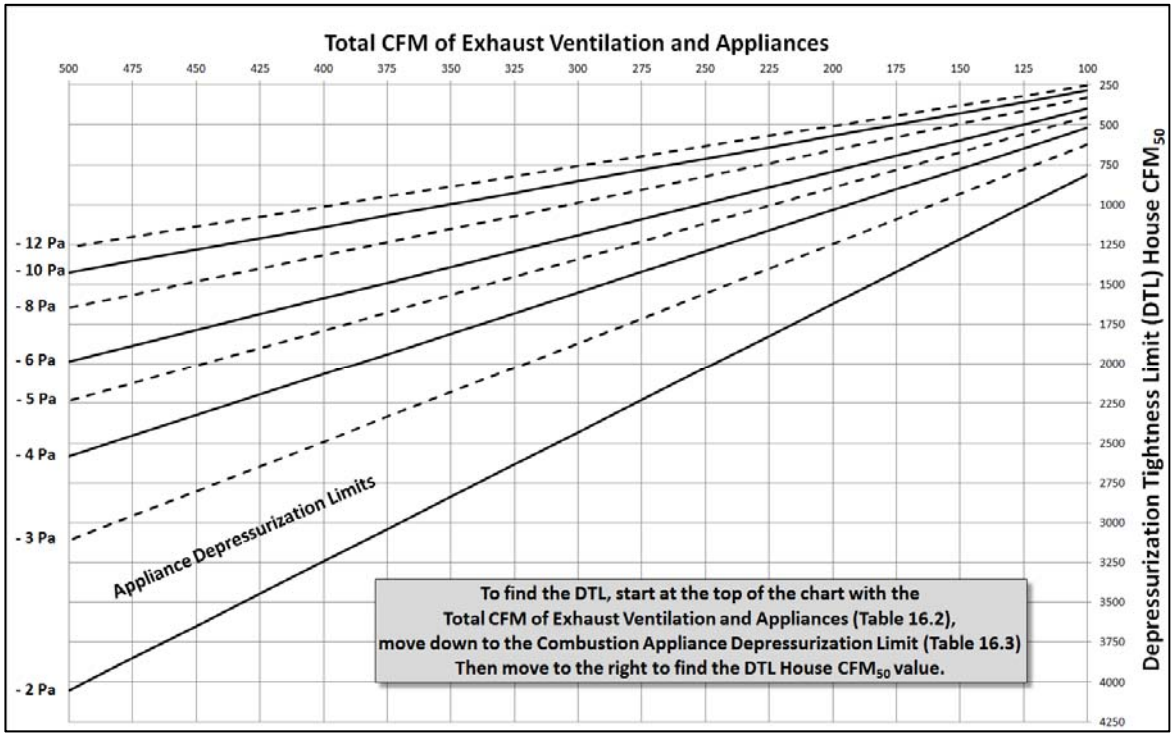


Table 16.2
Combustion Appliance Depressurization Limits

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

Adapted from Minnesota Energy Code 7672.0900 and Canadian General Standards Board 51.71.

2. Select the appropriate Combustion Appliance Depressurization Limit from Table 16.2. If there is more than one combustion appliance in the combustion appliance zone, select the Combustion Appliance Depressurization Limit for the appliance that is more likely to backdraft. For example, a water heater with a Limit of -2 is more likely to backdraft than a Category III gas furnace with a Limit of -15.
3. Using Chart 16.1, determine the CFM_{50} Depressurization Tightness Limit for combustion safety. Use this as a low limit to house tightening. For example, if the DTL is 1600 CFM_{50}, instruct the crew or contractor not to tighten to below 1600 CMF_{50}.
    a. Exception: If the DTL is less than 1000 CFM_{50}, use 1000 CFM_{50} as the tightening limit for the dwelling.

Remember, the DTL is a pre-weatherization guideline only; it must never be used to replace real-time combustion safety testing.

Table 16.3
Exhaust Appliance Nominal CFM

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

16.4 Furnace Temperature Rise Measurement

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

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

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

1. *Up-flow furnaces* (these are typically found in basements or closets):
    a. *Supply side:* Drill a hole and insert the thermometer in the supply plenum as close as possible to the heat exchanger, but "out of sight" of the heat exchanger (this ensures that the reading will not be affected by radiant thermal energy from the heat exchanger). It is preferred to drill a test hole near each of the four corners of the supply plenum, check the supply-air temperature in each, and average these readings for use as the supply temperature. If the furnace plenum

houses a central air conditioning coil, be very careful to avoid damaging this coil. Drill the hole beyond the cooling coil.

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

2. *Horizontal-flow furnaces* (these are typically found in crawl spaces or attics):
   a. Drill a hole and insert the thermometer in the supply plenum as close as possible to the heat exchanger, but "out of sight" of the heat exchanger (this ensures that the reading will not be affected by radiant thermal energy from the heat exchanger). If access is available, it is preferred to drill a test hole near each of the four corners of the supply plenum, check the supply-air temperature in each, and average these readings for use as the supply temperature.
   b. *Return side:* Drill a hole and insert the thermometer into the return plenum approximately 2 feet before the filter.
3. *Down-flow furnaces* (these are typically found in mobile homes.) The furnace compartment door should be closed while taking the temperature readings. The instructions below assume a living space return system, rather than a belly return system.
   a. Inspect and, if necessary, repair the plenum/furnace joint before measuring the temperature rise.
   b. Make sure all interior doors are open, including the furnace closet door.
      i. The furnace closet door should be a louvered door.
   c. Turn on the furnace and allow the temperature of the supply air to stabilize. Measure the temperature at the register closest to the furnace—supply air temperature—making sure that the airflow to this register is not blocked and that there is no significant duct leakage between the furnace and your thermometer.
   d. Subtract the return air temperature from the supply air temperature. The difference is the temperature rise.
      i. Test the return side air temperature by placing the thermometer probe at or through the slots in the blower compartment cover near the top of the furnace.
   e. 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. Undetected restriction in the ductwork.
   f. 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.
   g. 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.
4. Patch all test holes with an appropriate material.

16.5 External Static Pressure Testing

This test helps determine problems with the ductwork and/or the distribution fan.

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

Typical ESP values are from 0.5 IWC or 125 Pascals with a coil and filter and from 0.25 IWC or 62 Pascals without a coil and filter.

1. Find the manufacturer's recommended external static pressure value on the name plate of the unit. It is likely that this value will be in units of Inches of Water Column, rather than Pascals. Record this recommended value; it is the combined values of the supply-side and return-side static pressures, ignoring the negative sign of the return-side static pressure.
2. Make sure the furnace filter is in place. A clean filter is preferred.
3. With a static pressure tip connected to your digital manometer, measure both the supply- and return-side static pressure at the outlet and inlet of the blower by drilling measurement holes in the supply and return ductwork.
    a. In order to avoid turbulence, take readings 3 to 5 duct diameters downstream of the air handler blower.
    b. Don't measure air conditioning coil unless it shipped with unit. On some jobs, this will be difficult to determine. In all cases, document whether you measured the static pressure of the air conditioning coil or not.
        i. To measure the air conditioning coil static pressure, the hole for the static pressure tip connected to your digital manometer must be located downstream (after) of the air conditioning coil. Take care that the coil is not damaged by your activities.
        ii. To ensure that you are not measuring the static pressure of the air conditioning coil, locate the test hole upstream (before) the air conditioning coil. Take care that the coil is not damaged by your activities.
4. Add the supply- and return-side static pressures together—ignoring the negative sign of the return side pressure—to find the total external static pressure.
    a. This total ESP should fall within the range of the manufacturer's recommendations on the appliance label. If it does not, correct the problem and retest.
    b. It is preferred that the supply- and return-side static pressure values are of similar magnitudes. Restricted returns, usually undersized, are a common problem with ducted distribution systems. The energy auditor or heating system technician must determine if a restricted return should be repaired or not.
5. Patch all test holes with an appropriate material.

16.6 Duct Leakage Testing

16.6.1 Introduction

Duct leakage 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 combustion venting failure.

Ductwork leakage can take place: 1) within the confines of the conditioned enclosure of the building, or 2) to and from the outdoors.

Leakage to or from the outdoors wastes more energy than leakage within the confines of the thermal enclosure. 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 enclosure 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 IAQ appraisal and by performing the worst-case depressurization testing.

16.6.2 Pressure Pan Testing in Mobile Homes and Site-Build Dwellings with Ductwork Outside of the Thermal/Pressure Enclosure

1. Install the blower door for a depressurization test. Make sure the dwelling is set up for winter conditions.
2. Open all interior doors.
3. Make sure the furnace burner and air handler are off and will not start during the testing.
4. Remove the filter(s) from the duct system for the pressure pan test.
5. Temporarily seal outside combustion air inlets or venting 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 spaces outside of the thermal/pressure enclosure containing ductwork to the outdoors as much as possible. The ideal is to have a pressure of 50 Pascals from the house to these spaces. If the measured pressure is less than 45 Pascals, re-check to be sure all operable vents and other openings are fully open.
   a. Open skirting under the mobile home to the outdoor air.
   b. Open a site-build home crawlspace of basement to the outdoors.
   c. In attic spaces containing ductwork, open the attic as much as possible to the outdoors for the test.
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 dwelling 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 in the client file.
14. Refer to Sections 11.1.6 and 11.1.7 on pages 114 and 115 for duct leakage standards.

16.7 Combustion Safety Testing

16.7.1 Introduction

The purpose of combustion safety testing is to ensure the health and safety of the occupants. Combustion safety testing includes:

1. Measuring ambient CO concentrations throughout dwelling, but especially in the vicinity of combustion appliances.
2. Gas leak testing and fuel-oil leak inspection;
3. Inspection and CO emissions testing of gas ovens;
4. Worst-case combustion appliance zone (CAZ) depressurization;
    a. Under worst-case depressurization conditions, test natural draft, Category I combustion appliances for
        i. Spillage;
        ii. Adequate breech draft; and
        iii. Carbon monoxide emissions within the vent system. These measurements must always be taken in combustion gases before dilution are enters the vent system.

The importance of these tests cannot be overemphasized. If for any reason these tests cannot be performed, the reason(s) must be documented in the client file.

16.7.2 Measure Ambient Carbon Monoxide.

1. Upon entering the dwelling, the energy auditor will have their CO measurement instrument running in order to measure ambient concentrations of carbon monoxide.
2. If CO is detected at levels greater than 9 ppm, determine the source and correct the problem before proceeding.

16.7.3 Gas Leak Testing

1. Combustible gas leak testing will be done on all accessible natural gas and propane piping including where pipes connect to appliances.
   a. Allow ½-inch to one-inch space between the probe and the surface. Slowly scan the area being tested; about 1 inch per second. Test above the line for natural gas and below the line for propane.
   b. Verify any found leaks with a non-corrosive leak detection fluid.
2. All leaks must be repaired.

16.7.4 Fuel Oil Leak Inspection

1. Check the oil supply line from the oil tank to the heating unit for any evidence of leaks. Pay close attention to the fuel oil line as it exists the oil storage tank, at any line connections, and around the oil filter.
2. Any fuel oil leaks must be repaired.

16.7.5 Worst-Case Combustion Appliance Zone (CAZ) Depressurization Testing

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

The test results or any reason for not conducting the test must be documented.

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

16.7.5.1 Dwellings Requiring Worst-Case Depressurization Testing

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

The following are *exceptions* to this requirement:

1. If the house or mobile home is all-electric with no combustion appliances, wood stoves or fireplaces, or has appliances that are all sealed combustion (direct vent) or unvented (vent free), a worst-case depressurization test does not have to be performed.

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

16.7.5.2 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.

16.7.5.3 Procedure Setup

1. Place the building in the blower-door-test 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. Position all interior doors as you would for a blower door test.
   a. Be aware that wind will cause the pressure readings to fluctuate. During windy conditions, it will reduce pressure reading fluctuations if the pressure time average setting on the digital manometer is lengthened.
2. Record the outdoor temperature on the Residential Audit Tool 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.) If there is a furnace, replace or clean the filter if it is dirty.
5. Check and clean the lint filter in the dryer.
6. Set up pressure hoses so that the pressure differential of the CAZ with reference to the outdoors can be easily measured with a digital manometer. If the CAZ is in a basement, run a pressure hose to the outdoors through a window or door, and then close the window or door as tightly as possible without totally closing off airflow through the hose.
7. 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 Depressurization form.
   a. The baseline pressure should be taken with the CAZ door in the same position it was or will be for the blower door test.

16.7.5.4 Determining Worst-Case Conditions

1. Turn on all exhaust devices (except a whole-house exhaust fan) and record the pressure in the CAZ. The pressure created in the CAZ from the operation of these

exhaust fans is the difference between this value and the baseline pressure measured in step 8 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/central air conditioner, activate the blower to determine if/how much the furnace contributes to depressurization/pressurization. Record the pressure reading in the CAZ with reference to the outdoors. If the furnace/air conditioner blower makes the CAZ pressure more positive, turn it off for the remainder of the testing. If its operation contributes to a greater negative pressure in the CAZ, leave it running for the remainder of the testing.

   Caution: If the only way to activate the blower is to fire the furnace, extreme caution must be used due to the potential for combustion backdrafting or flame rollout. Try to activate the furnace blower without firing the furnace burner.

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

   Note: Room-to-room pressure testing and adjusting should have been completed before this worst-case depressurization test is performed. Refer to Section 11.2 on page 116 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. 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. Record the net worst-case depressurization; that is, the negative pressure of greatest magnitude in the CAZ with reference to outdoors after subtracting the baseline CAZ pressure.

16.7.5.5 Worst-Case Depressurization vs. Appliance Depressurization Limit

1. Compare the net worst-case depressurization with the appliance depressurization limits in Table 13-2. If the actual net worst-case depressurization is equal to or more negative than the appliance depressurization limit value in Table 15.2:
   a. Implement measures to rectify this hazardous condition by selecting the appropriate option in Section 16.7.5.6, number 6.

16.7.5.6 Verifying Proper Appliance Venting

1. NOTE: During this testing under worst-case depressurization, the analyst will continuously monitor ambient CO concentrations. If concentrations rise to a level of

35 ppm, the testing will be stopped and the area purged with fresh outdoor air. Before testing continues, the source of this CO must be mitigated.

2. Under these worst-case conditions, fire the combustion appliance with the lowest Btu input first. Check for spillage after two minutes of firing. If the appliance spills after two minutes, it fails the spillage test.
3. When the appliance reaches steady-state conditions (stable temperature in the vent connector) measure the breech draft at the appropriate location. The draft should comply with the draft values in Table 16.3 or 16.4. If the draft is weaker than the values in Table 16.3 or 16.4, the appliance fails the draft test.
4. After the appliance reaches steady-state (stable temperature in the vent connector) measure the CO in the vent connector of the appliance, ensuring that there is no room dilution air at the point of measurement. The CO value must be less than 100 ppm as-measured or 200 ppm air-free.
    a. If the CO levels are higher, the appliance must be cleaned and tuned and then retested for CO.
5. Fire all remaining appliances, one at a time, in order of input rating (smaller to larger) testing each one for spillage and breech draft. All appliances must achieve acceptable spillage and draft tests.
    a. If the appliances vent into the same chimney flue or vent connector, test each one individually.
    b. If the appliances vent into different chimney flues or vents, test with each successive unit running, that is, as you fire up the next appliance, allow the previous one to operate.
6. If spillage or breech draft measurement is unacceptable, correct the problem by one of the following methods (listed in order of preference):
    a. Inspect the vent system for blockage or restriction. Correct the problem.
        i. As a simple test to determine if the unacceptable spillage or breech draft test is caused by blockage or excessive negative pressure in the CAZ, open a window or door in the CAZ so that it is well connected to the outdoors. If the cause is for the bad draft or spillage is negative pressure, this will relieve the negative pressure, allowing the vent system to work properly. On the other hand, if the problem is caused by a restriction, the spillage/draft problem will remain. Keep in mind that there is the possibility that the venting problem could be the result of a blockage *and* excessive negative pressure in the CAZ.
    b. Inspect ducted distribution systems for return leakage in the CAZ. Seal any leakage to make the net worst-case depressurization less severe. Inspect ducted distribution systems for supply leakage in places other than the CAZ. Seal any leakage to make the net worst-case depressurization less severe.
    c. Increase the CAZ air volume by connecting the CAZ to other areas within the conditioned volume of the dwelling (see NFPA 54, NFPA 31 or NFPA 211.)
    d. Duct outdoor air directly to the burner(s)' combustion supply air port; or
    e. Increase the CAZ air volume by connecting the CAZ to the outdoors (see NFPA 54, NFPA 31, or NFPA 211).
    f. Supply outdoor air to the CAZ with a supply fan linked to the affected combustion appliance controls.

g. Replace the appliance with one that is more resistant to negative pressure in the CAZ. Replacements must be documented, with significant detail, in the client file.

7. If the dwelling has other combustion appliance zones, repeat the sequence of activating exhaust equipment, door closure, furnace blower activation, recording pressure readings, etc.
8. When all worst-case depressurization testing has been completed, turn off all exhaust equipment and return doors and combustion appliances to their previous operational settings.
9. Seal any holes that were drilled in the vent connector with appropriate materials.

Table 16.3
Gas Appliances, Category I
Acceptable Breech Draft Test Readings for Various Outdoor Temperature Ranges

ºF	<10	10 to 90	>90
Pascals (Pa)	-2.5	(Tout/40) - 2.75	-0.5
Inches Water Column (IWC)	-0.01	(Tout/10,000) - 0.011	-0.0002
"Tout is" equal to the Temperature outdoors, ºF.			

Table 16.4
Low-Static Pressure Power Oil Burners
Acceptable Draft Readings at Breech

Draft Reading Location	***Acceptable Draft***
Vent Connector or Breech	-0.04 to -0.06 IWC or -10 to -15 Pascals

16.8 Zone Pressure Diagnostics (ZPD)

16.8.1 Introduction

Zone pressure diagnostics testing is performed to answer some fundamental questions: where is the functioning air barrier and how leaky is it? These test procedures can also be used to measure the size of the leakage paths to various house zones. Leaking air often takes a path through two pressure boundaries that have a cavity, or zone, between them. These zones can include attics, basements, garages, knee-wall areas, or attached porch roofs. Please refer to Section 6.10 on page 66 for ZPD requirements.

ZPD testing is required by the West Virginia GOEO Program in all cases where additional information is needed regarding the relative and absolute leakage of air barriers (pressure boundaries,) including attics and attached or tuck-under garages. For example, CFM_{50} 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 dwellings with moderate air leakage, rather than on dwellings with very high or very low air leakage. All pressure and flow readings are required and must be documented.

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 chart. Once these flows are calculated, an estimate of the square inches of leakage through an air barrier can be determined.

16.8.2 Use of Zone Pressure Diagnostics

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.
4. As a way to help determine the location of the pressure boundary.

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, but it can also be misleading. Be cautious when interpreting the results of secondary zone testing.

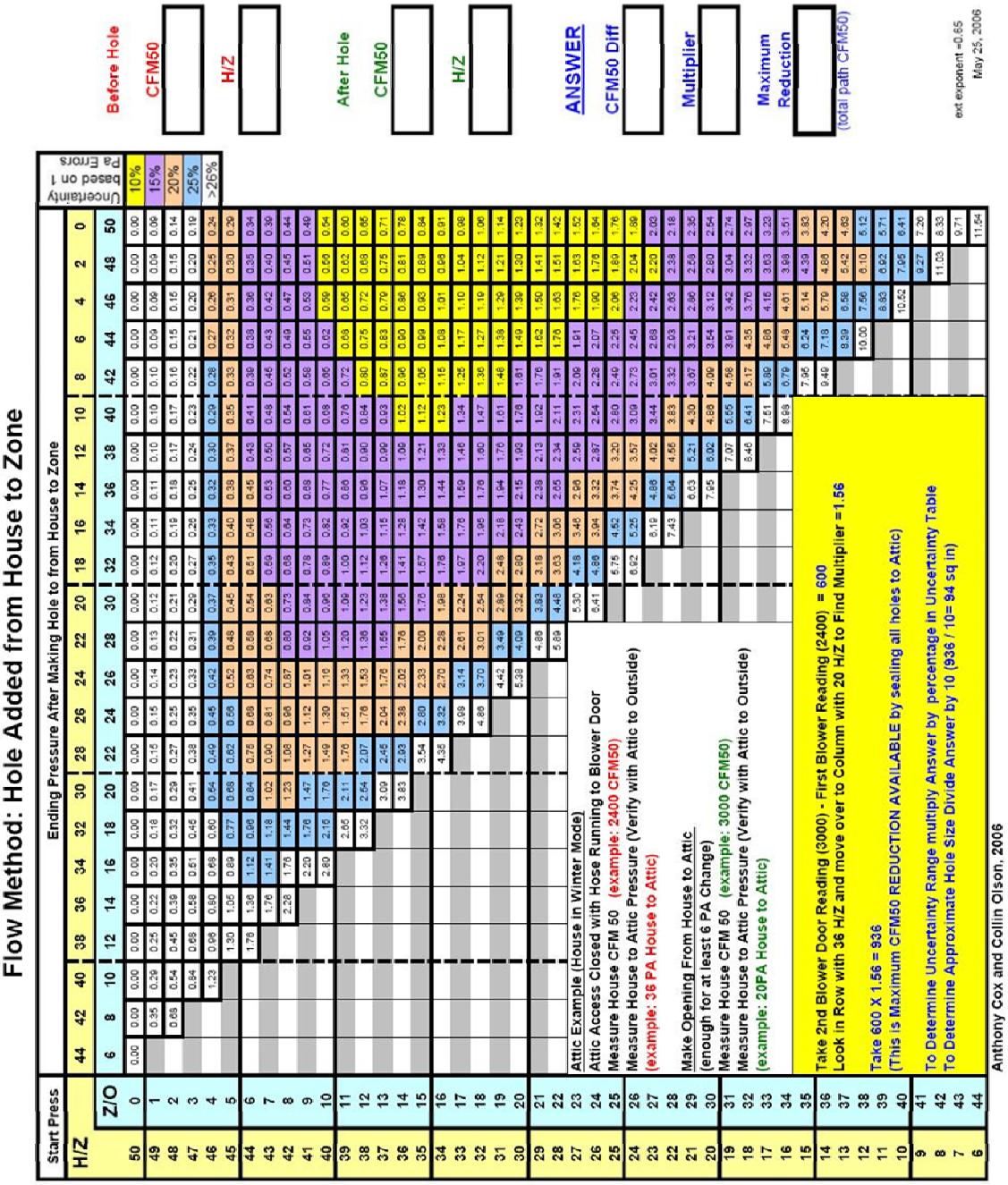
16.8.3 Test Procedures for Primary Zones

1. Use the color charts for the add-a-hole (flow) method (see pages 155 and 156) or the black and white charts (see pages 157 and 158) for the open-a-door method. Each method allows the hole or door to be opened between the house and the zone or between the zone and the outdoors.
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.
   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.

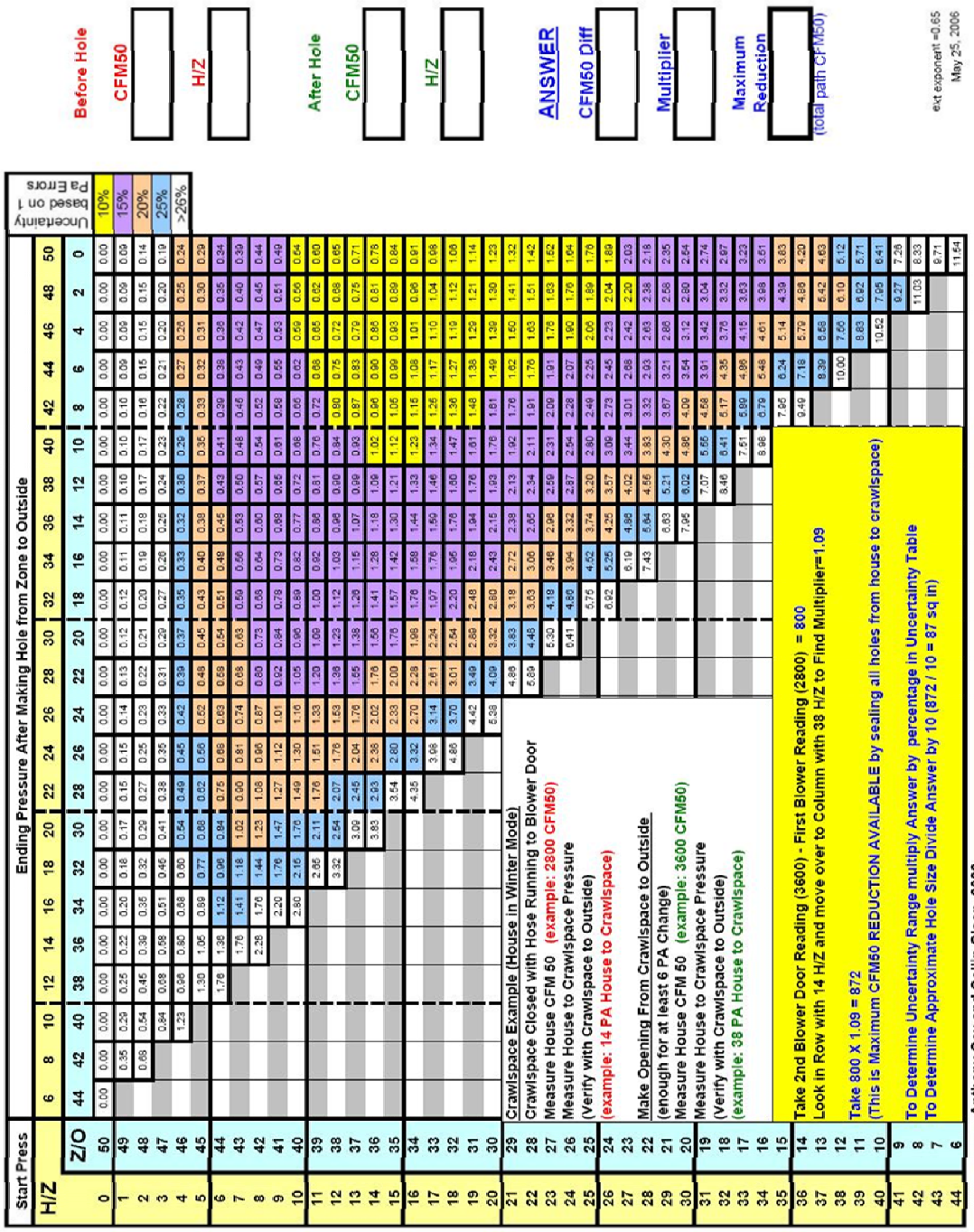
c. If the house is relatively tight for a dwelling of its size, there is probably no reason to perform basic ZPD testing for energy reasons. However, there might be reason to perform testing for moisture or indoor air quality concerns.

3. Identify zone types. ZPD can be done on all primary zones including attics, crawl spaces, basements, and attached or tuck-under garages. ZPD can also be done on some secondary zones, such as porch roofs and cantilevers that will be sealed off from the house.
4. For the detailed ZPD testing procedures, follow the instructions on the charts mentioned above and reproduced below or use the spreadsheet mentioned above.

16.8.3.1 Flow Method: Hole Added from House to Zone



16.8.3.2 Flow Method: Hole Added from Zone to Outside



16.8.3.3 Door Method: Opening Door from Garage to House

OPEN A DOOR (ZONE PRESSURE - SERIES LEAKAGE DIAGNOSTICS)

Open House Door to Garage

closed pressure		multiply CFM50 change by...		
H/G	G/O	int	ext	path
48	2	0.14	1.14	0.14
47	3	0.20	1.19	0.19
46	4	0.25	1.24	0.24
45	5	0.31	1.29	0.29
44	6	0.37	1.34	0.34
43	7	0.43	1.39	0.39
42	8	0.49	1.44	0.44
41	9	0.56	1.49	0.49
40	10	0.63	1.54	0.54
39	11	0.70	1.60	0.60
38	12	0.78	1.65	0.65
37	13	0.87	1.71	0.71
36	14	0.96	1.78	0.78
35	15	1.06	1.84	0.84
34	16	1.17	1.91	0.91
33	17	1.29	1.98	0.98
32	18	1.42	2.06	1.06
31	19	1.56	2.14	1.14
30	20	1.71	2.23	1.23
29	21	1.88	2.32	1.32
28	22	2.07	2.42	1.42
27	23	2.27	2.52	1.52
26	24	2.50	2.64	1.64
25	25	2.76	2.76	1.76
below here you should probably use other side of card				
24	26	3.04	2.89	1.89
23	27	3.36	3.03	2.03
22	28	3.73	3.18	2.18
21	29	4.14	3.35	2.35
20	30	4.61	3.54	2.54
19	31	5.15	3.74	2.74
18	32	5.77	3.97	2.97
17	33	6.50	4.23	3.23
16	34	7.36	4.51	3.51
15	35	8.38	4.83	3.83

Check G/O

Anthony Cox and Collin Olson, 2006

FOR OPENING THE DOOR FROM GARAGE TO HOUSE

All Doors to Garage Closed *(House in winter mode)*
Get Blower Door to -50PA WRT Outside

A Measure House CFM 50 for Door Closed
B Measure Closed Door Zonal Pressure House WRT Garage
(If Closed Door Zonal Pressure less than 25PA you should use other side of this Sheet)

Open Door from Garage to House
Get Blower Door Back to -50PA WRT Outside
C Measure House CFM 50 for Door Open
Measure Zonal Pressure House WRT Garage (Should be 0)

D CFM 50 Difference = CFM 50 Door Open - CFM 50 Door Closed

Look up Closed Door Zonal Pressure for House WRT Garage on Table

Enter Multipliers into labeled Multiplier Boxes Below
Multiply CFM 50 Difference (D) x Multiplier in each row for results

Divide CFM 50 by 10 in each row To Determine Approx. Square inches of Leakage

B	A	C	D
Closed Door Pressure House WRT Garage	CFM 50 Door Closed	CFM 50 Door Open	CFM 50 Difference (C-A)

Leakage from Garage to House

(D) CFM 50 Difference	Multiplier	CFM 50	Square Inches
	x (int)		

Leakage from Garage to Outside

(D) CFM 50 Difference	Multiplier	CFM 50	Square Inches
	x (ext)		

Total Path Leakage

(D) CFM 50 Difference	Multiplier	Maximum CFM 50 Reduction Available
	x (path)	

exponents=0.65 May 25, 2006

16.8.3.4 Door Method: Opening Door from Garage to Outside

OPEN A DOOR (ZONE PRESSURE - SERIES LEAKAGE DIAGNOSTICS)

Open Garage Door to Outside

closed pressure H/G	closed pressure G/O	multiply CFM50 change by... int	ext	path
2	48	1.14	0.14	0.14
3	47	1.19	0.20	0.19
4	46	1.24	0.25	0.24
5	45	1.29	0.31	0.29
6	44	1.34	0.37	0.34
7	43	1.39	0.43	0.39
8	42	1.44	0.49	0.44
9	41	1.49	0.56	0.49
10	40	1.54	0.63	0.54
11	39	1.60	0.70	0.60
12	38	1.65	0.78	0.65
13	37	1.71	0.87	0.71
14	36	1.78	0.96	0.78
15	35	1.84	1.06	0.84
16	34	1.91	1.17	0.91
17	33	1.98	1.29	0.98
18	32	2.06	1.42	1.06
19	31	2.14	1.56	1.14
20	30	2.23	1.71	1.23
21	29	2.32	1.88	1.32
22	28	2.42	2.07	1.42
23	27	2.52	2.27	1.52
24	26	2.64	2.50	1.64
25	25	2.76	2.76	1.76
below here you should probably use other side of card				
26	24	2.89	3.04	1.89
27	23	3.03	3.36	2.03
28	22	3.18	3.73	2.18
29	21	3.35	4.14	2.35
30	20	3.54	4.61	2.54
31	19	3.74	5.15	2.74
32	18	3.97	5.77	2.97
33	17	4.23	6.50	3.23
34	16	4.51	7.36	3.51
35	15	4.83	8.38	3.83

Garage is leakier to the house than it is to the outdoors. (rows 2–20)

Anthony Cox and Collin Olson, 2006

FOR OPENING THE DOOR FROM GARAGE TO OUTSIDE

All Doors to Garage Closed *(House in winter mode)*
Get Blower Door to -50PA WRT Outside

A Measure House CFM 50 for Door Closed
B Measure Closed Door Zonal Pressure House WRT Garage
(If Closed Door Zonal Pressure greater than 25PA you should use other side of this Sheet)

Open Door from Garage to Outside
Get Blower Door Back to -50PA WRT Outside
C Measure House CFM 50 for Door Open
Measure Zonal Pressure House WRT Garage (Should be 50)

D CFM 50 Difference = CFM 50 Door Open - CFM 50 Door Closed

Look up Closed Door Zonal Pressure for House WRT Garage on Table

Enter Multipliers into labeled Multiplier Boxes Below
Multiply CFM 50 Difference (D) x Multiplier in each row for results

Divide CFM 50 by 10 in each row To Determine Approx. Square inches of Leakage

B Closed Door Pressure House WRT Garage	A CFM 50 Door Closed	C CFM 50 Door Open	D CFM 50 Difference (C-A)

Leakage from Garage to House

(D) CFM 50 Difference	Multiplier	CFM 50	Square Inches
	x (int)		

Leakage from Garage to Outside

(D) CFM 50 Difference	Multiplier	CFM 50	Square Inches
	x (ext)		

Total Path Leakage

(D) CFM 50 Difference	Multiplier	Maximum CFM 50 Reduction Available
	x (path)	

exponent=0.65 May 25, 2006

17 Glossary

- A -

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

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

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

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

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

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

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

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

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.)

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.

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

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

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

Atmospheric Burner – A burner utilizing *atmospheric combustion*.

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

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

- B -

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

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

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

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

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

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. Also known as “band board.”

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

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

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

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

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

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

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

Breech Draft – The draft or pressure difference between the combustion appliance zone and the inside of the vent connector above or downstream of the combustion appliance. The breech draft is usually checked about 12 inches from the appliance.

Breeching or Breech – See Vent Connector.

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.

Btuh – British thermal units per hour.

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

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

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

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

- C -

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

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

Caulking – A mastic compound for filling joints and cracks.

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

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

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

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

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

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.

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

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

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

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 output in Watt-hours of heat removed, divided by Watt-hours of electrical input.

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

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

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

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

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) – Room and enclosed air volume that contains a combustion appliance. This may include, but is not limited to, a mechanical room, mechanical closet, or main body of the house.

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

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

Compact Fluorescent Lamp (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.

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

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

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

Condensate – The liquid formed when a vapor is condensed.

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

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.

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. Sometimes referred to as “open combustion.”

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 enclosure 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.

CFM_{50} – The number of cubic feet per minute of air flowing through the fan housing of a blower door when the house pressure is 50 Pascals (0.2 inches of water 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 CFM_{50}, to estimate the building tightness level at which combustion appliances might backdraft when the house is under conditions of worst-case depressurization.

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

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

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

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

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

DHW – Domestic Hot Water

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

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

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

Draft Diverter – See Draft Hood.

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

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

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

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

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

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 building shell. The exterior walls, floor, and roof assembly of a building. Also referred to as building enclosure.

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.

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)

Enclosure – The building shell. The exterior walls, floor, and roof assembly of a building. Also referred to as building envelope.

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

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.

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

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

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

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

Flammable/Inflammable – Combustible; readily set on fire.

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

Floor 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.

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

- 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.

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

Gas Oven Broiler Burner – Oven burner used for broiling located at the top of the oven compartment.

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

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

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

Ground 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 or crew.

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.

HWAP – Home Weatherization Assistance Program.

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

HUD – United States Department of Housing and Urban Development.

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

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

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

- I -

IAQ – Indoor Air Quality

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

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

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

Induced Combustion – See Fan-Assisted Combustion.

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

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

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

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

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

allows all the combustion supply air to be taken from the CAZ if the outdoor air inlet becomes blocked.

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

Insulation – A material used to retard heat transfer.

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

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

Interstitial Space – Space between framing and other building components.

- J -

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

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

- K -

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

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

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

- L -

Lamp – A light bulb.

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

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

Lead Safe Work Practices (LSW) – 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.

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

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

Lumen – A unit of light output from a lamp.

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

- M -

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

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

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

Manometer – A differential gauge used for measuring pressure.

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

Masonry – Stone, brick, or concrete block construction.

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

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

MHEA – Manufactured Housing Energy Audit, developed by the Department of Energy for weatherization assistance programs. Used to audit 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 Draft – A vent system that relies on natural draft (buoyant air) to move combustion gases to the outdoors. *Comment: Category I appliances; atmospheric, fan-assisted, or power burner type combustion; sometimes direct-vent; might be through-the-wall vented.* (Based on NFPA 54)

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

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

NEMA – National Electrical Manufacturers' Association

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

NFPA – National Fire Protection Association.

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

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

- O -

O_2 – Oxygen.

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

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

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

Open-Combustion Appliance – A combustion appliance that takes its combustion supply air from the surrounding room. Contrast this with direct-vent or sealed combustion appliance.

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

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

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

- P -

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

Pascal (Pa) – A metric unit of measurement of air pressure. 2.5 Pa = 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.

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

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

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

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

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.

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

Power Draft – See Mechanical Draft.

Pressure – 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 venting.

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 boilers burner on and off as steam pressure changes.

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

- R -

R-value – A measurement of thermal resistance.

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

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

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

Radon – A radioactive gas that decomposes into radioactive particles.

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

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

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

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

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

Relay – An automatic, electrically operated switch.

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

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

Retrofit – An energy conservation measure that is applied to an existing building. Also, the action of improving the thermal performance or structural condition of a building.

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

Rim Joist – The outermost joist around the perimeter of the floor framing. Also known as “band joist” or “band board.”

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 Life of a measure is discounted with factors published by the Department of Energy every April.

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.

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

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.

SHPO – State Historic Preservation Office.

Sheetrock – See Drywall.

Shell – The building's exterior enclosure – 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.

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.

Sone Level – An international unit used to measure sound levels. One Sone is equivalent to the sound of a quiet refrigerator in a quiet kitchen.

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 Enclosure – The boundaries of a dwelling that serve to envelop the space to be kept warm during cold weather and cool during warm weather. The surfaces of the thermal enclosure usually serve as a thermal and pressure barrier.

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

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

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

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

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

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

Type IC recessed electrical fixture – An electrical fixture that is rated to be in direct contact with thermal insulation.

- 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 enclosure that is not heated or cooled, but tends to be the same temperature as outside.

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

UL – Underwriter's Laboratory.

- V -

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

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

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

Vaporize – To change from a liquid to a gas.

Vent Connector – The pipe that connects the combustion appliance to a vent or chimney.

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

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

Venting – The removal of combustion gases by a chimney.

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

Vermiculite – A heat-expanded mineral used for insulation.

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

- W -

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

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

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

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

WAP – Weatherization Assistance Program.

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

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

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

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

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

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

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

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