NEW MEXICO ENERGY$MART TECHNICAL STANDARDS

Low-Income Weatherization Assistance Program

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1 GENERAL PROGRAM REQUIREMENTS

1.1 Effective Date

All weatherization measures performed or completed by the agencies on or after the date specified in the cover letter to these Standards shall comply with these Standards.

1.2 Energy$mart Technical Standards Waivers

A. Deviations from the Standards require a waiver from the Mortgage Finance Authority (MFA) Weatherization Program Manager prior to expenditure of funds. Work may proceed after verbal authorization by the MFA Weatherization Program Manager. An electronic or hard copy documenting authorization will be forwarded and kept in the client file.

B. Waivers may be granted by MFA in the following cases:

   a. The Department of Energy (DOE) Weatherization Assistance Program (WAP) does not permit the general practice on non-renewable fuel switching when replacing furnaces/appliances. However, DOE does allow the changing or converting of a furnace or appliance using one fuel source to another on a limited, case-by-case basis only.

   b. If a client/occupant refuses to allow a certain measure to be completed and this measure has a higher savings-to-investment ratio (SIR) than the remaining measures. Agencies should explain the potential energy savings to the client to ensure that they understand the ramifications of their decision. Agencies must document the reason the work was not performed.

   c. 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 address an unsafe venting situation, but only on a case-by-case basis.

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 conversions must be completed by qualified personnel in compliance with applicable building codes.

1.2.1 Emergency Situations, Immediate Follow-up Required

Some safety problems may warrant discontinuing the combustion appliance testing or shutting off the appliance until the repairs can be made. Whenever a technician questions the safety of a situation, they should consult a supervisor. The local natural gas or propane supplier should be called whenever possible. Examples of this type of situation are:

A. *Propane or natural gas leak:* Propane can be smelled more than three feet from the leaking fitting.

B. *Clogged or disconnected flue:* A clogged or disconnected flue that cannot be fixed, causing significant spillage of combustion byproducts into a heated space or working area of the technician.

C. *Cracked furnace heat exchanger:* Any visually identified cracked heat exchanger leaking combustion byproducts.

D. *Other hazards:* Any other situation or combination of situations that the technician or supervisor judges hazardous to the health of the client or others.

1.2.2 Non-Emergency One-day Follow-up Recommended

Some situations may not warrant discontinuing testing or shutting down the heating system but are serious enough to require attention within 24 hours. Examples of this type of situation are:

A. If carbon monoxide measured in the heated space exceeds levels listed in Sections 11.7.5 (gas oven testing) or 11.7.6 (worst-case depressurization testing).

B. There is spillage.

C. A furnace with no limit switch, or a limit switch that is disconnected.

1.2.3 Non-Emergency Five-day Follow-up Recommended

All other safety-related follow-up must begin within five days. Examples of this type of situation are:

A. Spillage in an unheated area that does not comply with the procedures in Section 11.7.6 (worst-case depressurization testing).
B. A furnace limit switch that does not shut the gas off by 225°F.
C. A cracked heat exchanger is suspected, but there are no other apparent problems with the furnace.

2 PRE-WEATHERIZATION ENERGY AUDIT, ENERGY AUDITS, AND FINAL INSPECTIONS

2.1 General Energy Audit Requirements

A. All measures installed in a dwelling must be included on the Recommended Measures Report, either as an energy-saving measure (ECM), a health and safety measure, or an incident repair (IR) item.
   a. The cost of the incidental repairs must be included in the cost of the bundle of measures installed in a dwelling, and auditors are responsible for ensuring that the home has a cumulative savings-to-investment ratio (SIR) of 1.0 or greater for the combination of IRs and ECMs.
   b. Service providers may be liable for repayment to the program for any measure that is not included on the Recommended Measures Report.
   c. The energy auditor is responsible for ensuring that all energy-efficiency measures achieve a SIR of at least one, with the exception of air sealing that can be less than 1.

B. Each client file must have an accurate estimate/work order and Recommended Measures Report generated by the energy auditor responsible for the job. An acceptable Recommended Measures Report is one for which all installed energy-saving weatherization measures have a savings-to-investment ratio of 1.00 or greater.
   a. Measures for which SIR values are less than 1.00 are ineligible.
      i. Exception: Air sealing can be less than 1.00.
   b. All energy-saving measures must be considered and ranked in order of descending SIR. Installing a measure with a lower SIR without installing others with greater SIR is forbidden. In other words, significant measures may not be skipped without a waiver from MFA.
   c. The input report must be included in the client file.

C. The work order must clearly itemize the work to be completed by the contractor or agency crew. The work order must include:
    a. Targets for both infiltration and duct sealing.
    b. Funding category (ECM, IR, H&S)
    c. Funding source (DOE or BIL, LIHEAP, Utility, State)
    d. Reference to field guide and/or SWS.
    e. Be well organized and legible.
    f. Include all appropriate dimensions and quantities.
    g. Include any appropriate special instructions for necessary inspections or unusual installations.
    h. The method of insulation installation with the proposed amount, type, and R-value of the insulation to be installed.
    i. The name, the principals and business mailing address of the firm providing and installing the insulation.
    j. Details of any warranties on materials used in the home.
    k. A written description of any work required for the installation of the insulation, including who will do the work and who will pay for it.
    l. Identify any hazards at the job.
    m. Document reasons for installing health and safety measures in client file using "Health and Safety" form.

2.2 Energy Audit Requirements

A. The energy audit must include as a minimum:
    a. The date the energy audit was run. Under no circumstances should the audit have a date other than the actual date it was run.
        i. An audit that is re-run shall have a different date-time stamp than the initial energy audit.
    b. Information about the existing condition of the dwelling and its mechanical systems, including heating and cooling systems
    c. Diagnostic tests, including:
        i. Combustion appliance analysis of steady-state efficiency;

ii. Forced air furnace assessment, including:
    1. Visual ductwork inspection.
    2. Dominant duct leakage test.
    3. Room-to-room pressure balance test, section 11.3.3.
    4. Pressure pan testing, as required by these standards.
    5. For ducts outside the thermal boundary, the subtraction method is required in addition to pressure pan testing. See instructions here for more detail: http://energyconservatory.com/wp-content/uploads/2017/08/Blower-Door-Subtraction-Method.pdf
iii. Furnace heat rise and static pressure testing, sections 11.4 and 11.5;
iv. All gas and liquid-fueled combustion appliances, regardless of venting type, must receive combustion safety testing, including:
    1. Carbon monoxide testing,
    2. Checking for gas leaks, Section 11.7.3.
    3. Testing of gas ranges, Section 11.7.5.
    4. Combustion appliance zone (CAZ) depressurization, Section 11.7.6. At worst-case depressurization, carbon monoxide shall be tested in the vent connector and a spillage test shall be done.
v. Blower door testing, sections 11.1 and 11.8, including:
    1. Whole-house test to find CFM50 and determine integrity of air barrier.
    2. Attic thermal bypass assessment.
    3. Leakage from tuck-under garages.
    4. Leakage from attached garages.
    5. Leakage from attic spaces.
    6. Leakage from crawlspace or basement.
    7. Leakage from any space containing possible contaminants (example: outdoor water heater closet).

d. Health and safety problems, including possible lead paint, moisture and/or mold, electrical problems, signs of rust and corrosion on combustion appliances. The Health and Safety Inspection Check List must be filled in and signed by the client;

e. Existing insulation levels. R-values for fiberglass should be adjusted according to Section 5.2.2;
f. Conditions the contractor/work crew needs to know 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. Moisture problems;
j. Baseload energy usage, including a record of the last 12 months of utility bills data;
k. Client energy usage problems; and
l. Indoor air quality (IAQ) assessment, including ventilation for acceptable IAQ and:
    i. Identification of potential contaminant sources.
    ii. Measurement of existing exhaust fan flow rates.
    iii. Determination of ASHRAE 62.2-2016 minimum whole-house ventilation rate.

B. Work orders must effectively communicate to the contractor/work 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 work;
    d. Analysis of warehouse inventory as it relates to the job, if applicable.

2.2.1 Final Inspection Procedures

The final inspector may perform minor adjustments to previously installed retrofits in order to attain satisfactory results. Such adjustments must not exceed one working hour per unit and will not be considered a "weatherization retrofit" as noted above.

The following tests and inspections must be performed during the final inspection:

A. Quality and quantity of materials installed, including verification that all measures on the work order have been installed and work has been completed as intended;
B. Review of the input report for quality control;

C. Installation standards/work quality;

D. A post-weatherization blower door test to verify reported post-weatherization CFM50 value;

   a. Final blower door must be within 25 percent of target . If the number is 25% higher than the target, and there is nothing indicated in the client file from the crew field notes explaining the reason, the inspector must fail the job and write a rework order.

      i. The inspector must look for areas of leakage with the blower door running that can be remedied to be included on the rework order.

      ii. If the reading is lower than target, the inspector must verify that the ASHRAE RED Calc includes the correct blower door entries. If the entries are incorrect, the inspector must re-run the calculations and adjust the fan accordingly.

E. Health and safety tests, including combustion safety tests (section 11.7 for required combustion safety tests);

F. If duct sealing was performed, the inspector must perform the following tests and visual inspections:

a. Visual ductwork inspection.

b. Dominant duct leakage test.

c. Room-to-room pressure balance test.

d. Pressure pan testing.

When there are obvious areas that have not been addressed visually with the ducts, including balancing the room-to-room pressures, the inspector compares the pressure pan readings with the assessor's, and the field notes from the crew. If the final inspector can determine that between the visual inspection and pressure pan readings, that any one duct is failing the inspection, a rework order is issued with photos of the ducts and pressure pan readings.

G. Furnace heat rise and static pressure testing;

H. Completion of the Weatherization Final Inspection Form; and

I. Client signature(s) verifying completion of work.

2.2.2 General Requirements – Quality of Work

A. At no time during the job shall the agency crew or contractor store any materials and tools in living areas of the dwelling. Tools and materials shall be placed in proper storage chests or job trailers at the end of each workday.

B. Any exterior wood trim installed on the home should have all six sides primed. Care shall be taken to ensure that the new trim blends into the existing character of the home and is of equal or better quality.

C. Any interior materials installed on the home should be of material to match the existing trim located in the home.

D. All materials being installed by the agency crew or contractor shall be installed to closely match the existing trim or finish material that is adjacent to the newly installed trim.

E. Building permits, electrical permits, plumbing permits and other permits required by local or state authorities shall be obtained by the agency crew or contractor. Permits must be obtained prior to commencement of work.

F. Workmanship and materials not covered by manufacturers' warranties shall be warrantied by the contractors for a period of at least one year from date of final payment to the contractor. All manufacturers' warranties shall be delivered by the contractor to the agency for inclusion in the final job packet.

G. All repair work shall conform to the local and/or state building codes when applicable.

2.2.3 General Final Inspection Items

A. The inspector is responsible for ensuring all items specified in the work order have been completed in a professional manner.

B. The inspector shall assess the job to ensure that the agency crew or contractor have not damaged any existing finishes and/or items in the home.

C. The inspector shall also ensure that the contractor or crew have left the dwelling in a clean and orderly manner.

D. The work order and applicable rework(s) shall be followed at all times during the final inspection and any items that have not been completed to the satisfaction of the inspector must be noted on an agency Rework Order.

E. Any required rework shall be completed in a timely manner and must be verified by the original inspector.

F. If a Rework Order is issued, the inspector must return to the dwelling for another inspection after the rework has been completed.

G. The inspector is responsible for obtaining all the proper homeowner signatures on the final sign-off for the project.

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

I. Client or scheduling obstructions to final inspection:

    a. New Mexico MFA 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.

    b. Documentation regarding attempts to contact must be put in the client file, signed by the inspector and the agency weatherization director, indicating the dates when the agency attempted to inspect the residence.

        i. The agency should notify the client in writing to explain that the agency was unable to complete a full on-site inspection.

        ii. If the client does not respond within two weeks, the agency should contact New Mexico MFA for documented approval to report the unit as a completion.

J. After all work on the dwelling has been completed and approved by the inspector, the inspector must sign and date the Weatherization Final Inspection Report. His or her signature certifies that the dwelling has been inspected, that the work was satisfactorily completed and that all materials charged for were properly installed.

K. No dwelling unit may be reported to the New Mexico MFA as a completed unit until the administering agency has performed a final inspection and certified that applicable work has been completed in a workman-like manner and in accordance with the procedures established for the New Mexico Energy$mart Program. Any dwelling

presented to New Mexico MFA but not post-inspected can constitute contract breach and non-compliance by the agency.

2.3 Client Education Recommendations

A. Client education should be provided during all phases of the weatherization process. This includes, but is not limited to:
    a. The client intake and scheduling. Explain:
        i. What the client should expect.
        ii. How the weatherization process will proceed.
        iii. Who will call next.
    b. The initial field inspection. Discuss:
        i. What the client should expect during the energy audit.
        ii. Air leaks discovered with the blower door.
        iii. Any health and safety issues, such as:
            1. Lead paint.
            2. Asbestos-like materials.
            3. Combustion venting.
            4. Carbon monoxide.
            5. Mold and mildew.
            6. Plumbing leaks.
            7. Animal hazards such as rodent feces or insect infestations.
            8. Electrical hazards.
            9. Other possible hazards.
        iv. Health and safety issues should be addressed both verbally and by distributing educational pamphlets during the audit "walk-through." This can be particularly effective as the auditor notices and discusses potential hazards.
        v. Energy conserving measures that will be installed, such as:
            1. Air sealing.
            2. Additional insulation.
            3. Heating system improvements.

4. Air conditioning improvements.
5. Baseload reduction measures, including water heater improvements.
6. Low-flow plumbing fixtures (shower head or aerator). If one is installed in conjunction with lowering the domestic hot water temperature, the chances are high that the client will not notice less hot water for showering, as they might if the temperature is reduced without installing the new showerhead.

vi. Improvements in the thermal comfort of the dwelling as a result of the weatherization.

vii. An explanation of gas range safety and proper use. Refer to Section 11.7.5.

viii. An explanation of required maintenance for existing equipment, added equipment, or energy-saving measures.

ix. What will take place after the initial inspection:
   1. Schedule of events.
   2. Who will contact the client next.
   3. When the work will be complete.

x. Work the client must do to prepare for the weatherization.
   1. Moving stored items to make room for the weatherization work.
   2. Any other actions that must take place before the weatherization work begins.

c. Health and Safety

i. Carbon Monoxide (CO) Poisoning and CO alarms.

ii. The client must be informed by the weatherization staff regarding:
   1. How CO poisoning occurs.
   2. How the alarm operates, including the expected life of the alarm, after which time they will be responsible for replacement.
   3. The dangers of chronic low levels of CO (i.e., from 5-70ppm CO) for those people with respiratory problems, the elderly, young children, and pregnant women.

iii. If the CO alarm sounds, or if the client has observed continuous readings below the level that activates the alarm:

1. Recommend that they call their heating contractor or fuel provider to examine their appliances, as this level is an indication of problems with the combustion appliances and poses a health risk to people vulnerable to low-level exposure.
2. If the detector sounds, the client should assess the situation quickly for potential causes for alarm. At-risk individuals should be evacuated immediately.
3. If it is determined that there is a problem after the first or second alarm, the client should call the local fire department and move to the outdoors immediately. If the alarm sounds, it means the levels of CO have reached a dangerous level and immediate action is required to ensure their safety. Refer to the manufacturer's instructions.

d. 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 may reduce the client's energy bill and improve their comfort.
e. Window air conditioners. 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:
    i. Removing the unit and closing the window, or
    ii. Installing an airtight cover on the exterior of the air conditioning unit, or
    iii. Sealing the air conditioning unit from the exterior.
f. The final job inspection.
    i. The inspection personnel should reinforce the advantages of the energy-saving measures installed.
    ii. The client should always be asked if they have any remaining questions regarding the weatherization or health and safety work that was done.

iii. The inspection personnel should explain to the client how the dwelling will perform differently as a result of the installed weatherization measures.

g. Whenever possible, demonstrate to educate. Get the client involved in the educational process, if possible. The use of up-to-date written materials is encouraged, but demonstration has proven to work better in most cases.

3 HEALTH AND SAFETY REQUIREMENTS

Each home weatherized must be assessed individually 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 NM Energy$mart 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:

A. 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 or excessive levels of chipping and peeling of lead paint in pre-1978 homes. This is of particular concern on interior surfaces and components.
    e. Mold or mildew.
    f. Radon precautionary measures must be performed in all homes regardless of the presence of radon. These measures include:
        i. Provide the client with EPA's consumer guide to radon and inform them of radon related risks.
        ii. Clients sign a consent form prior to receiving services.
        iii. Whenever conditions permit, exposed dirt must be covered with a vapor-permeable ground cover.

iv. Other precautions thatmust be taken to reduce the likeliness of making radon concentrations higher include but are not limited to:

1. Sump pump/well pits covered with airtight covers where applicable.
2. ASHRAE 62.2-2016 must be implemented.

v. Sealing foundation penetrations, ensuring crawl space venting is installed and operable.

vi. Radon mitigation is prohibited when using DOE funds.

vii. Limited radon testing is an allowable expense in areas with high radon potential.

B. Air quality assessment, including:

a. Interviewing client(s) regarding health conditions of occupants with the intent of determining if air quality is acceptable.

b. Determination of ventilation needs for ensuring acceptable indoor air quality. Mechanical ventilation requirements shall be based on *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, ASHRAE Standard 62.2-2016*.

C. Combustion systems assessment, including:

a. Combustion safety testing, including worst-case depressurization spillage 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.

D. Assessment of crew, contractor, and client safety concerns.

a. All materials stored on the job site for weatherization work 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 for lead-safe work practices.

E. Reclaim any refrigerants using procedures of the Clean Air Act 1990, section 608, as amended by 40 CFR82, May 14, 1993.

3.1 General

A. Correction of pre-existing code compliance issues is not an allowable cost other than where weatherization measures are being conducted. State and local codes must be followed when installing weatherization measures.

B. Correction of fire hazards is allowed when necessary to safely perform weatherization.

C. Pest removal is allowed only where infestation would prevent weatherization.

3.1.1 Injury Prevention for Occupants

A. Minor repairs may be done when weatherizing a home only when it is necessary prevent injury to weatherization workers and occupants during weatherization. These repairs may only be done to the extent of ensuring safety. This work must be less than 10 square feet total. These minor repairs might include:

a. Lowering domestic hot water temperature, only when low flow devices are installed.

b. Repairing stairs, when used by workers to enter and exit the home.

c. Repairing decks and balconies, only to effectively carry out weatherization activities.

3.2 Combustion Appliances and Heating Systems

A. Repair and replacement of inoperable or unsafe primary combustion appliances is allowed, including the installation of direct-vent, sealed-combustion appliances.

a. Repair and cleaning should be done before replacement is considered.

b. Proper venting to the outdoors, including gas dryers and range hoods, is required.

i. Correction of venting is allowed when testing indicates a problem.

ii. Secondary systems may be repaired or removed, but not replaced.

B. System repair, replacement or installation is allowed of red-tagged, inoperable, or non-existent primary heating systems where climate conditions warrant. Secondary systems may be removed or repaired, but not replaced.

3.3 Stand-Alone Electric Space Heaters

Minor repair stand-alone electric space heaters is allowed.

A. Check the electrical circuitry to ensure adequate power for existing space heaters.

B. Inform client of hazards of use and have client sign a waiver if removal is not allowed by the client.

C. Removal is recommended. However:

a. Stand-alone electric space heaters may be used as a temporary heat source during weatherization if the primary heating system is disabled.

b. When these units are the client's only heat source, the house must be modeled according to the energy audit procedures under, "missing systems".

3.4 Spray Polyurethane Foam Use

Spray polyurethane foam is a widely used and highlyeffective 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.

A. When working within the thermal envelope with spray polyurethane foam, follow EPA guidelines or manufacturer's guidelines.[1]

B. When using spray polyurethane foam outdoors, isolate the area where the foam will be applied and take precautions to ensure the fumes will not be transferred to the indoor living area.

C. Make sure all state and local fire codes are followed when spray polyurethane foam is used indoors.

[1]

3.5 Asbestos Inspection Procedures

A. Because there is the possibility that the weatherization testing or work may disturb materials that contain asbestos, the energy auditor must inspect for such materials prior to beginning work.

B. Decisions on approaches to weatherization work where asbestos is present shall be based on the judgment of the most qualified individual available to the agency.

C. 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.

D. All agency workers must wear high-quality respirators any time they work with asbestos.

E. When working with materials containing asbestos, the materials should be dampened with water whenever possible to reduce the risk of airborne asbestos fibers.

F. Materials containing asbestos may not be cut, drilled or disturbed in any manner that may cause asbestos fibers to become airborne.

G. 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.

H. 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.

I. 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.

3.6 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 School" 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. Publications must be received by the occupant no less than seven (7) calendar-days prior to the commencement of weatherization work, and no more than 60 calendar-days prior to the commencement of work.

Lead-Safe Weatherization (LSW) must be applied to all pre-1978 housing (site-built and mobile homes) unless there is existing evidence that EVERY component to be disturbed in the home has been certified as being lead-free. One of the following methods must be used to determine the paint to be disturbed as non-lead-based paint.

A. Written determination by a certified lead inspector or risk assessor; OR
B. Proper use of an EPA-recognized test kit by an EPA-Certified Renovator (per EPA final rule LRRP) provided that the agency properly document the manufacturer, test kit model, description and location of tested components and the test results.

Containment consists of any and all work processes, barriers, and engineering controls intended to limit the production of, and control the distribution of, dust and debris generated during the installation of a weatherization measure. For the purposes of LSW, containment is broken into two different levels and may be different for each measure to be installed in the home.

A. Level 1 Containment.
    a. Level 1 containment is required in pre-1978 homes when less than 6 feet of interior painted surface per room or 20 feet of exterior painted surface will be disturbed.
    b. Level 1 containment consists of methods that prevent dust generation and contain 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.

B. Level 2 Containment.

a. Level 2 containment is required when weatherization activities will disturb more than 6 feet of interior surface per room or 20 feet of exterior surface 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 the 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: machines to remove paint through high-speed operation without HEPA exhaust control. Note that the use of a drill, reciprocating saw, or other power tool is considered a "machine" for removing paint. For example: Cutting an attic hatch

inside the dwelling or interior drilling of holes for the installation of insulation require level 2 containment.

d. Additionally, the following activities are prohibited regardless of containment:
    i. Open-flame burning or torching.
    ii. Operating a heat gun at temperatures at or above 1,100°F.

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

D. New Mexico 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.

E. Weatherization of HUD program housing stock, including HUD Section 8, is infrequent in New Mexico. These units will only be weatherized if HUD will provide certification that abatement or control of any lead paint hazard has been addressed and will agree that the local agency will not be liable for any lead hazards, provided the safe work practices generally outlined above are employed.

F. 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 shall 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.

3.7 Moisture Remediation, Assessment, and Repair

Return to Section 8.3 Moisture Problems (Mobile Homes)

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/estimate, the work performance period or the quality control inspection. Other funding sources should be sought to cover the cost of cleaning or cleaning moldy surfaces.

In New Mexico, excessive moisture might be a problem. Common measures for dealing with potential moisture problems include:

A. Repair or installation of bathroom and kitchen exhaust fans.
B. Installation of ground moisture barriers of 6-mil black plastic under enclosed foundation mobile homes, houses receiving sidewall insulation or any house with excessive dampness in the crawl space.
C. Air sealing and duct sealing.
D. Removal of unvented space heaters.
E. Repair or installation of dryer vents to be properly vented to beyond the perimeter of the crawl space or basement.
F. Sealing attic bypasses to prevent air from carrying moisture into an attic.
G. Adding crawl space venting, but only when appropriate (per NFPA or other applicable code).
H. Replacement of downspouts and/or gutter sections to divert moisture away from the dwelling may be done with MFA approval.

3.8 Energy-Related Mold and Moisture

Moisture, mold and mildew can affect seriously the health and safety of the client and crew. Steps must be taken to alleviate moisture problems. The New Mexico Weatherization Program shall ensure that regular weatherization work is performed in a manner that does not contribute to the increase of any mold problems and, when the work is performed properly, can alleviate many mold conditions.

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

3.8.1 Assessment of Moisture Conditions

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

A. A moisture assessment must be conducted with special attention to the following signs:
    a. Evidence of condensation on windows and walls indicated by stains or mold.
    b. Standing water, open sumps, open wells, dirt floors, water stains, etc. in basements or crawlspaces. Also, check to see if firewood is stored in the basement and whether laundry is hung to dry during the winter months.
    c. Leaking supply or waste pipes.
    d. Attic roof sheathing that shows signs of mold or mildew.
    e. Active roof leaks.
    f. Dryer fan and bath exhaust fan ducting that is non-existent, damaged or constricted, too long or not connected to outdoors.
    g. Presence of unvented space heaters.

B. Identification of existing or potential moisture problems shall be documented in the client file.

C. If existing moisture problems are found, the source of the moisture must be reduced or the home must be deferred. In some cases, air sealing can reduce the source of the moisture (i.e., sealing off crawlspaces from the house, or sealing attic air leaks to eliminate condensation on the roof deck). It is up to the assessor to make this determination before work proceeds.

D. Because air tightening may cause an increase in relative humidity, client education should include information about moisture problems and possible solutions.

E. In the course of weatherization, any low-cost measures that help reduce the humidity levels in the home should be installed. Examples of these activities are venting dryers to the outdoors, venting existing bath or kitchen exhaust fans or installing moisture barriers on dirt floors.

3.8.1.1 Mitigation of 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).

a. If it is determined that the problems are too sever under the scope of weatherization, a Deferral of Service form shall be signed at the time of inspection and left with the client and a copy placed in the client file.
b. 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.
c. The agency should try to refer the client to other programs or agencies that may be able to assist in resolution of the problem.

3.8.1.2 Mitigation of Moisture, Mold or Mildew – Mitigation as Part of Weatherization

A. If an existing moisture, mold or mildew problem is found and the agency determines that the job can be completed or cleaned under the scope of the Weatherization Program, then:
    a. The agency will have the client sign the Health and Safety Report informing the client of the existing problem(s), leaving a copy with the client (or mailing a copy to the client) and a copy in the client file.
    b. 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.
    c. The agency will repair or eliminate the moisture problem and weatherize the dwelling in accordance with program regulations.
    d. 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.

3.8.1.3 Dryer Vents

A. Electric and gas dryers must always be vented to the outdoors.
    a. **See SWS 6.0202.1, and NM Field Guide 17-1 .1a Clothes dryer ducting for additional requirements and installation procedure.**
B. Extend mobile home dryer vents through the skirting to the outdoors.
C. Dryer vent ductwork should be smooth surfaced. No more than 90° elbows may be used in the vent system, and the ductwork should not exceed 15 feet. If three 90° elbows are required, the total length of the vent may not exceed 10 feet. Alternately, the duct diameter can be upsized 1-2 inches.

3.9 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. All homes must comply with ASHRAE 62.2-2016. There are no exceptions.

ASHRAE 62.2-2016, *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*, shall be used for the installation of ventilation systems, both local ventilation and whole-building ventilation.

Existing operable fans that will remain in place and serve as part of the ventilation system shall be measured for Cubic Feet per Minute (CFM) of airflow. This airflow shall be recorded.

A. Bathroom ventilation
    a. Must 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. Must 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 A.a. or A.b. above, it must be provided or Appendix A of ASHRAE 62.2-2016 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.

B. Kitchen ventilation
   a. Must 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 Air Changes per Hour (ACH); or
   b. Must 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 B.a. or B.b. above, it must be provided or Appendix A of ASHRAE 62.2-2016 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.
   e. Make-up air should be provided for kitchen fans exhausting more than 200 CFM.

C. Whole-building ventilation operating continuously shall be no less than 7.5 CFM (number of bedrooms + 1) + 3 CFM per 100 square feet of conditioned floor area
   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 (HRV). 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 shall be determined Red Calc ASHRAE 62.2-2016 Ventilation https://www.redcalc.com/ashrae-62-2-2016/

i. The infiltration credit for single family is included in the Red Calc and is based on ASHRAE 119 and 136, and
ii. The local ventilation alternative compliance supplement (Appendix A of ASHRAE 62.2-2016) shall 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 shall be documented in the client file. This decision shall 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 MFA.

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

D. Fan sound ratings
a. Fan sound ratings shall be equal to or less than the ratings in Table 3-1.

Table 3-1 Maximum Fan Sound Ratings

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 62.2-2016.		

E. Ductwork

a. Ducts outside of the thermal envelope shall be insulated to a minimum of R-8 per NM Field Guide 18-1, 18-2 and **SWS 6.0101.1 Selection of duct insulation material and support.**

b. Rigid ductwork with a smooth interior surface is recommended over flexible ductwork.

c. Duct support

i. Rigid metal ducts will be supported at intervals of 10 feet or less. Supports shall have a width of at least ½ inch.

ii. Flexible ducts will be supported at intervals of 4 feet or less. Supports shall have a width of at least 1½ inches.

d. Duct runs shall be as short as possible and shall have not more than one elbow of a maximum of 90 degrees.

e. Kitchen fan ductwork shall be rigid, smooth metal of at least 28-gauge wall thickness.

f. Rigid ducts

i. Metal-to-metal or metal-to-PVC connections shall be fastened with a minimum of at least three equally-spaced screws.
ii. PVC-to-PVC joints shall 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.*

g. Flexible ducts
    i. Shall 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 shall be fastened with tie bands using a tie-band tensioning tool.

h. Duct terminations, exhaust
    i. Termination fasteners shall not inhibit damper operation.
    ii. Galvanized hardware cloth with no less than ¼ inch and not greater than ½ inch hole size will be used to exclude pests.
    iii. Metal or other approved material shall be used for the termination fitting for kitchen exhaust.
    iv. 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.

i. Exhaust grille location
    i. For local bathroom or kitchen exhaust, the grille shall 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 shall be located at a central location within the main body of the dwelling.

iii. For whole-building ventilation when no local ventilation is present, the grille shall be installed in the bathroom that is likely to have the highest moisture generation.

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

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

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

iii. System shall be set up to provide filtration of air before reaching the air handler system. Intake fillers shall be accessible for maintenance, shall not produce ozone and the occupant shall 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 shall 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 shall be measured during commissioning.

F. Attached garage exhaust fans

a. Any ventilation in garages shall be exhaust only.

b. Leakage between the garage and the living area of the dwelling shall be tested for leakage according to Section 11.8.

G. Instructions, labeling and client education[2]

[2] Please refer to the current New Mexico State Plan, available at: http://www.housingnm.org/community_development/energysmart

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 shall be reviewed with occupants.
c. Controls shall be labeled as to their function, unless that function is obvious (such as on-demand bathroom exhaust switches).
d. Client shall be asked to sign a document attesting to the fact that they have been informed about the installed ventilation system.

H. Commissioning
   a. Air flows of local bathroom and kitchen fans and whole-building fans shall be measured after installation to ensure that the design CFM airflow has been achieved.

3.10 Combustion Safety Testing

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 may be existing indoor air quality conditions that may be intensified by air sealing techniques.

A. Therefore, the following health and safety measures must be performed on all combustion appliances of weatherized homes.
   a. Measurement of ambient carbon monoxide concentrations should be done. If any ambient level of CO above 9 ppm is found, the source must be identified and the problem corrected.
      i. The energy auditor should enter the dwelling with their CO measurement instrument running so that they can check the ambient CO concentration throughout the dwelling.
      ii. An ambient air test for CO should be taken on coal, wood, unvented heaters and gas cook stoves.
   b. A CO test of undiluted flue gases must be done on all vented combustion appliances. If a CO level above 100 ppm as-measured 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.

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 tests on all Category 1 natural gas, LP gas and oil appliances must be performed under worst-case depressurization conditions to ensure an adequate 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. Identify the combustion air source and make sure it is unobstructed and sufficient, as defined by NFPA code.

B. A detailed description of these tests can be found in Section 11.7.

C. 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 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 completed.

3.11 Carbon Monoxide Alarms

A. At least one CO alarm must be installed in each weatherized dwelling. Alarms must be installed in accordance with the manufacturer's instructions, local codes, and NFPA 72 guidance. One alarm must be placed within 21 feet of any sleeping room on each habitable floor, and in any sleeping room that contains a combustion appliance. If an entire multifamily building is to receive weatherization services, a CO alarm must be installed in each unit of the complex in accordance with NFPA 72.

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 liquid propane.

b. Unvented space heaters are expressly prohibited in weatherized homes unless they are a secondary heat source and comply with Section 7.4.5.C. Under no circumstances may an unvented space heater remain in a mobile home.

B. All installed CO alarms must:
   a. Be listed as UL 2034 listed and compliant.
   b. Have a 10-year warranty.
   c. Have a digital LCD display.
   d. Contain instructions that are provided to the occupants.

C. 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.

D. The cost of the CO alarm or combination CO and smoke alarm is a health and safety material cost.

3.12 Smoke Alarms

If smoke alarms are inoperable or non-existent, at least one alarm must be installed in each weatherized dwelling. If existing hard-wired smoke alarms are inoperable or broken, they must be replaced with comparable units. Smoke alarms must comply with the Health and Safety Plan, NFPA 72, and **SWS 2.0101.**

- All smoke alarms must be installed in each sleeping area, within 21 feet of each sleeping area, and on each occupiable floor.
- Alarms must contain 10-year batteries.
- Occupants must be provided with the manufacturer's written instructions.

3.13 Electrical Safety

3.13.1 Knob-and-Tube Wiring

A. Where live knob-and-tube wiring exists, the agency must mitigate all risks before weatherization measures can be taken. The following conditions must be met in order to install attic insulation:
    a. If funds are available, it is preferred to remove or deactivate live knob-and-tube connections.
    b. If the wiring is not deactivated:
        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 must use a licensed electrician where questionable safety conditions exist.
        iii. When installing cellulose or fiberglass, there must be a minimum of 3-inches clearance from the knob-and-tube wiring. When cellulose is installed, precaution must be taken to prevent the possible drifting of the product, which could result in contact with the wiring.
        iv. **Refer to NM Field Guide 4-1 for additional procedures.**
B. The presence of knob-and-tube wiring, overloaded circuits, live bare wires, or moisture in the wall cavities less than 12 square feet must be remedied prior to insulating. The agency must determine what category of funding or funding source will be used such as Health and Safety, Weatherization Readiness, or state funds. Major measures such as insulation mut be evaluated for cost-effectiveness. If the hazards cannot be abated with funding sources and categories that allow abatement activities, and measures can't be safely implemented, the job must be deferred.

3.13.2 Junction Boxes

All visible electrical connections must be inside approved electrical junction boxes. These junction boxes must have appropriate covers and must be flagged when concealed with insulation.

3.13.3 Ground-Fault Circuit Interrupter Devices

A. Test ground-fault circuit interrupter (GFCI) devices to ensure that they are working properly in dwelling bathrooms and kitchens.

3.14 Exceptions

Return to Section 11.1 Blower Door Testing

A. 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 the occupants.

B. 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.

C. 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. Other conditions where a blower door test might not be required include:

    a. An open (non-airtight) solid fuel appliance is in operation at the time of the energy audit or inspection. In such cases, it is often possible to postpone the blower door test until the solid-fuel appliance is not combusting.

D. All required testing shall be done to the extent allowed by law.

E. For any required testing that is not done, the reasons for omitting the test must be documented in the client file. Photos of potentially hazardous conditions or materials should be included.

4 AIR SEALING GUIDELINES

Return to Section 8.5 Air Leakage Reduction Requirements (Mobile Homes)

Although no prescriptive list of treatments is applicable to every dwelling type, there are treatments that typically are cost-effective when applied to most dwellings. Air sealing is cost-effective in the vast majority of dwellings; the difficulty is determining the amount of air sealing to do. In all cases, air sealing should be continued in a dwelling until it is no longer cost-effective. The procedures below are intended to help the crew or contractors find the cost-effective level of air sealing.

It is important to remember that when air sealing, an air barrier or pressure boundary is being created. It is best if this pressure boundary is:

A. Aligned with the thermal boundary (insulation);
B. Airtight and continuous;
C. Durable so that it will last as long as the insulation with which it is aligned.
D. Tested for tightness and thoroughness before insulation is installed.
    a. As an exception to this, dense-packed wall insulation serves as a good insulator (thermal boundary) and it also serves as an air barrier (actually a retarder). Unless there are holes in a wall large enough to allow loose insulation to escape, air sealing does not need to be done before installation of dense-packed wall insulation.

Air leaks can be found in a number of ways. These include:

A. Use of an infrared camera before and then during the initial blower door test (when the temperature differences between the outdoors and indoors are large enough, allow the blower door to run 10-15 minutes to allow the surface to cool/warm in order to clearly see results)
B. Observing tracer smoke movement while a blower door is depressurizing/pressurizing a dwelling.

C. Almost fully closing an interior door while a blower door is depressurizing/pressurizing a dwelling and using your hand to feel for airflow through the small opening of the door.
D. Looking for dirt marks on existing fiberglass insulation. The fiberglass filters out the dirt, which is what you see deposited on the fiberglass.
E. Spiders tend to build webs near airflow to catch insects. Where there are webs, there is usually air leakage.
F. Watching spider webs or other objects move in the airflow created by a blower door.
G. Listening for airflow (whistles) during a blower door test.

Air sealing shall begin with gross air sealing and then move to blower door-guided air sealing. It is preferred to have a blower door set-up so that the effectiveness of air sealing can be measured as the crew or contractor progresses through the process.

4.1 Gross Air Sealing

Gross air sealing includes obvious large holes, missing envelope components like window glass or door panels, missing sheetrock holes in the walls, floors or ceiling, or doors or windows that are stuck open. Eliminating these air leaks always is cost-effective. The initial blower door test should be done before gross air sealing.

4.2 Blower Door-Guided Air Sealing

As the name suggests, blower door-guided air sealing utilizes a blower door during air sealing activities to guide the process. Operate the blower door in depressurization mode while inspecting for leaks. Do not forget to check for leaks in a conditioned basement. If inspecting for leakage in an attic, it is best to pressurize the dwelling with the blower door by reversing the blower door fan.

Use blower door-guided air sealing after the items on the assessor's work order have been addressed, and the target has not been met. In instances where there are no obvious air leaks, and the number is still more than 25% higher than the target, the assessor must be contacted for instruction on how to proceed. The reasons for not being within 25% of the target must be clearly documented on the field notes.

Air leaks are to be sealed from the largest openings first and progressively working to the smaller leaks.

A. 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.
B. 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. NOTE: Always seal the attic properly *before* installing attic insulation.
C. In mobile homes seal the plumbing chase behind washer and dryer, water heater closet, under/behind bathtub and around the electric panel box.
D. Seal all duct leaks, both supply and return lines if the ducts are located in unconditioned spaces such as attics or crawlspaces.
E. Seal or install dampers in other openings such as dryer vents, kitchen and bathroom exhaust fans, window air conditioners, unused fireplaces and flues, etc.
F. Install dense pack sidewall insulation in all walls separating conditioned living space from exterior or unheated spaces, using the methods described in these Standards. A blower door test should be done to assess the status of the air sealing work.
G. Openings in recessed light fixtures must not be sealed unless the fixture is rated as a "Type IC" (zero clearance) fixture. However, non-Type IC recessed light fixtures may be boxed with a non-combustible enclosure in the attic.

H. If additional air sealing is needed, move on to these areas that are generally less effective. Such measures can include:
    a. Tightening 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.
    b. Sealing doors with weatherstripping, sweeps and thresholds. Make doors operate properly and replacement of entry locks as necessary.
    c. Caulking on the interior at baseboard, window and door trim. This should only be done after walls are dense packed with cellulose and the operation of the blower door with tracer smoke indicates these areas are leaking.

4.2.1 Air Sealing and Damming Around Chimneys and Vents

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

A. **Refer to NM Field Guide 3-1 Seal Around Chimneys and Flues.**
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.

4.3 Room-to-Room Duct-Induced Pressures

Room-to-room pressure(s) should be measured in all rooms with forced air heating return or supply ducts and operable doors with the air handler operating after all weatherization installations have been completed, but before post-weatherization combustion safety testing is performed.

For instructions regarding this test, please see Section 11.3.3.

4.4 Zone Pressure Diagnostics

Zone Pressure Diagnostics (ZPD) testing is recommended in some dwellings. ZPD testing is helpful in the determination of the location of the pressure boundaries and the effectiveness of air sealing measures. For example, ZPD is very useful before and after air sealing attic bypasses to determine the effectiveness of the air sealing. Additionally, the air tightness of a common

wall between a house and an attached garage can be measured with ZPD, both before and after air sealing.

Please refer to Section 11.8 for ZPD testing procedures.

4.5 Duct Leakage

Return to Section 7.5.2 Central Space Cooling Equipment, Section 7.5.4 Heat Pumps, Section 7.6.1 Ductwork Inspection, Cleaning and Sealing, Section 8.9 Ductwork (Mobile Homes) or Section 8.10 Floor (Belly) Insulation

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

Duct leaks can be 1) within the confines of the 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 crawlspaces or attics are susceptible to leakage to and from the outdoors.

Although duct leakage within the thermal/pressure envelope usually does not have a significant energy impact, it might impose a hazard to occupant health by causing poor indoor air quality or back-drafting 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. Additionally, pressure pan testing must be performed in site-built homes that have ductwork in spaces outside of the thermal/pressure envelope to help determine which ducts are the largest contributors to any leakage. For duct evaluation, the subtraction method must be used. Please refer to Section 7.6.7, Ducted Distribution Requirements, for more information. Also refer to Section 11.6 for duct leakage testing procedures including the subtraction method.

5 INSULATION REQUIREMENTS

5.1 Insulation Guidelines

Adding insulation to the building shell is often the most cost-effective measure performed in the Weatherization 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. The R-values of common insulation materials are listed below in Table 5-1.

Table 5-1 R-Values Per Inch for Common Insulating Materials

R-Values Per Inch for Common Insulating Materials	
Insulating Material	**Avg. R-Value Per Inch**
Mineral wool	3.2
Fiberglass batt	3.2
Vermiculite	2.1
Perlite	2.7
Cellulose*, open-blow in attic	3.7
Cellulose*, dense-packed	3.4
Fiberglass (loose fill)	2.2
Rock Wool (loose fill)	2.2
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
* For the New Mexico weatherization program, cellulose insulation must be the borate-only grade.	

5.2 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.

5.2.1 Inspection, Preparation, and Repairs

A. Prior to installing insulation, a thorough inspection of the attic area must be performed by the energy auditor and then by the installers.
    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. An additional description of allowable and necessary repairs is noted below. When extensive roof repair or a replacement is required, other funding must be solicited to offset the cost.
    c. Attics should be tested for air leakage between the ceiling and attic space either 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. Attic sealing needs to be performed before insulation installation.

5.2.2 Determining the Effective R-value of Existing Fiberglass Insulation

Return to Section 2.2 Energy Audit Requirements

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

A. For existing insulation other than fiberglass:
    a. Measure the average thickness of the insulation. Multiply the R-value per inch from Table 5-1 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 voices. Use a weighted-average calculation to find the effective R-value of the existing insulation/voids. A calculator to find this value can be found here: https://www.redcalc.com/parallel-path-r-value/

B. 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 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 5-2 Effective R-Values for Fiberglass Batts

Effective R-Values for Fiberglass Batts			
Measured Batt Thickness Inches	"Good" Effective R-value of 2.5 per inch	"Fair" Effective R-value of 1.8 per 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.

5.2.3 Attic Air Leakage

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

B. Ensure the air leakage (attic bypasses) have been sealed before attic insulation is installed. Use zone pressure testing, infrared equipment or tracer smoke in combination with blower door to verify air leakage has been treated adequately.

C. When appropriate, replace non-IC type recessed lights with IC-type before any new insulation is installed. New lighting must comply with local and state codes. The newly installed insulation may be in contact with the IC-type recessed fixtures.

5.2.4 Moisture Inspection and Repair

A. Roof leaks and all other attic moisture problems shall be repaired prior to the installation of attic or roof insulation.

B. 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.

C. Repair any moisture problems that will degrade or diminish the effectiveness of weatherization measures.

5.2.5 Attic Access

A. There must be access to the attic provided for post-work inspection and potential future needs of the client.

B. A gable vent on a hinged plywood or OSB door is considered adequate access.

C. An adequately-sized gable vent held in place with screws (no nails) is acceptable if building a hinged door is impractical.

Refer to NM Field Guide 5-1, 5-2 Dam, Seal & Insulate Attic Hatch,

DAM, SEAL & INSULATE A PULL-DOWN ATTIC STAIRWAY.

A. When it is necessary to install an interior attic access in the ceiling, it must be:
    a. At least 16 inches by 20 inches; or
    b. Wherever existing framing allows, a code-compliant access of at least 22 inches by 30 inches (ref. 2009 IRC 807.1); and
    c. Shall be weatherstripped and insulated to the same level as the attic floor or with a least 4 inches of extruded polystyrene (R-20).

B. In pre-1978 homes, installation of an attic access must be performed using lead-safe work practices and all dust and debris caused by the installation shall be wet-cleaned unless testing has confirmed the work area to be lead free.

C. An attic ceiling access shall have an insulation dam on the attic side, 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 such a 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.

D. If there are no interior accesses, at least one exterior access to each attic space shall 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 and 24 inches high, and shall be weather-stripped and insulated to the same R-value as the knee wall. At least

one latch shall 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 post-work inspector before the area is sealed off. The insulation in the sealed knee wall area must be documented adequately in the client file with photo documentation.

E. If the attic access has pull-down stairs, a zipper insulating tent or prefabricated rigid insulation box is allowed.

5.2.6 Attic Access Insulation NM Field Guide Section 5-1, SWS 3.0103.1g

Any interior access hatch to the attic shall be weather-stripped and insulated to the same R-value as the adjoining insulated assembly that is secured properly to the exterior surface of the attic hatch. Refer to Section 5.2.5.

5.2.7 Insulation Shielding and Blocking

A. All electrical fixtures must be verified to not be a fire hazard and contain the proper protection such as closed junction boxes. When an electrician is at the jobsite to install the ventilation fan, it is recommended to have the electrical fixtures checked prior to insulating.

B. No insulation, including fire-rated insulation, shall be installed above recessed light fixtures so as to trap heat or prevent free air circulation. However, insulation may be installed over Type IC light fixtures.

C. Blocking must be installed so that it is effective in shielding the heat source from the insulation, and no insulation shall be left within the blocked area.

D. Metal blocking must be notched as that it does not contact electrical wiring.

Refer to 4-1 PREPARE ATTIC FLOOR FOR INSULATION.

a. In addition to stopping the flow of air around a chimney, a block must be installed to keep insulation away from the masonry or metal chimney. *This is to*

be done with a block of rigid material. If this material is not fire-rated, it must be at least 2 inches from the masonry or metal chimney, per IRC.

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.

5.2.8 Treatment of Other Hazards

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

B. Repair any rotted, broken or damaged attic structural components. Ensure that the ceiling will safety hold the weight of the weatherization workers and the insulation. Repair or replace any weakened, damaged or missing interior ceiling surface.

5.2.9 Installation Methods for Attic Insulation

A. Locate and seal attic thermal bypasses, chases and partition walls open to the attic. 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 sealed completely before installing any insulation.

B. Attic insulation must cover heated/cooled areas completely and must be installed at an even depth, except where physical constraints exist.

C. Insulation must be installed to the outside edge of the top plate of an exterior wall.

D. Insulation may not cover soffit vents or fill the eave/soffit area. Added insulation shall not restrict the airflow through vents. Rigid baffles of cardboard, rigid foam or other appropriate material should be used at the soffit area to ensure venting and prevent loose insulation from entering the soffit area. **Refer to NM Field Guide 4-1 Prepare Attic Floor for Insulation.**

E. Insulation must be installed according to the manufacturer's specifications for coverage and R-value.

F. If the installation of cellulose insulation on top of existing batt or blanket insulation is warranted, cut or pull back existing fiberglass batts 1-2 feet from the soffit and blow the perimeter.

G. Cellulose is the preferred insulation to be installed in the attics of site-built homes.

5.2.10 Insulation Coverage and Density

A. Insulate uninsulated open-joist attics to at least R-38 in climate zones 3 and 4, to at least R-49 in climate zone 5, and to at least R-60 in climate zones 6 and 7; unless a NEAT audit calculation for the dwelling supports a different cost-effective level of insulation[3].

B. If existing insulation is in place, use NEAT/MHEA to determine if it is cost effective to add insulation and, if so, the cost-effective amount to add.

C. Insulation installers shall install gauges and labels per **SWS 4.0103.2a-e**

D. 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.

E. Insulate knee wall cavities as follows:

   a. Blown cellulose at a density of 3.5 to 4.5 lb/ft^3.
   b. Blown fiberglass at a density 1.6 lb/ft^3.
   c. Fiberglass batt insulation.
   d. Rigid foam board insulation.
   e. 2-part foam insulation.

F. Where feasible, densely packing cellulose insulation with an appropriate hose or tube might help air seal 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 is installed.

G. Calculating the number of bags, as per manufacturer's specifications from product supplied, is the preferred method for determining the proper amount of density of material to be installed into an attic area at a given R-value.

H. When it is cost effective, it is preferred that airtight floors be built over the soffit drop, making it a part of the attic deck, before attic insulation is installed.

I. Add insulation as necessary to eliminate voids and areas of incomplete coverage.

[3] Please refer to *2099 New Mexico Energy Conservation Code* to find climate zone designations.

5.2.11 Vaulted or Sloped Ceiling or Roof Cavities

A. Vaulted ceiling or sloped ceiling/roof cavities if enclosed, shall be densely packed to the same density as section 5.2.10. For open accessible vaulted and sloped ceilings with truss construction, follow the same method as in section 5.2.9.

B. Any flammable insulation or flammable insulation coverings must be protected with a 15-minute fire-rated material, such as ½ inch drywall mudded once, or ¾ inch of wood. If blown insulation is used, it shall be dense packed in the vaulted or sloped ceiling/roof cavities.

5.2.12 Knee Wall Areas

A. Knee walls shall be insulated in a manner like exterior walls when they separate conditioned from unconditioned spaces.

B. Whenever possible, knee walls should be insulated with dense pack cellulose insulation.

C. They may also be insulated with fiberglass batts with a vapor barrier/retarder on all sides, rigid foam board insulation or 2-part foam insulation. Consider the most cost-effective method for each situation.

D. **Refer to NM Field Guide 8-1 Air Seal Above the Knee Wall.**

5.2.13 Enclosed Ceiling or 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.

Refer to SWS 4.0102.3 Inaccessible Ceilings for material and installation requirements.

5.2.14 Storage Space

A. Where attic space is being used for storage before the attic is weatherized, agencies should request the client remove storage items from the area before the crew begins the job.

B. In cases where the client is physically unable to perform this task and is unable to solicit help from a family member or friend, agencies and contractors may include the removal of items in the cost-effective analysis of installing insulation and proceed with the measure if it is cost-effective (if the job has an overall SIR of 1.00 or greater).

5.2.15 Attic Ductwork Insulation NM Field Guild 20-1 through 20-4

A. Ductwork in attics must be sealed appropriately with the proper materials (duct mastic) before insulation is installed. Refer to Section 7.6 for instructions.
B. When working ducts are located outside of the thermal envelope, install a minimum of R-8 per on ducts and plenums.
C. 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.
D. If ductwork outside of the thermal envelope 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.

5.2.16 Floored Attic Insulation

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

5.2.17 Attic Venting

Attic venting should be installed when needed, but no attic should be over-ventilated because it 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.

5.2.17.1 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 venting openings should have suitable louvers and screens to prevent snow, rain and insects from entering the attic.

5.2.17.2 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-end vents at least three feet (when possible) above the soffit or a gable vent used for low venting.

5.2.17.3 Gable Vents

A. Gable-end vents should be installed as high in the gable as possible and positioned to provide cross venting.
B. Precautions shall be taken to block wind from "washing" insulation near the attic vents.

5.2.17.4 Roof Vents

A. 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. If roof vents are installed on the flat roof surface, they should be nailed and well-sealed to the roof to prevent water leakage.
D. Roof vents are not to be installed over rafters.
E. Roof vents should be tucked under shingles as much as possible. Surface-mounted roof vents are not allowed. **Refer to NM Field Guide 25-1 Install Roof Vent for additional instructions.**

5.2.17.5 Knee Wall Venting

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

5.2.17.6 Attic Vent Area Guideline

A. When attic venting is installed, IRC R806.1 and R806.2 shall be followed as listed below:
    a. Enclosed attics and enclosed rafter spaces formed where ceilings are applied directly to the underside of roof rafters shall have cross ventilation for each separate space by ventilating openings protected against the entrance of rain or snow. Ventilation openings shall have a least dimension of 1/16 inch minimum and 1/4 inch maximum. Ventilation openings having a least dimension larger than 1/4 inch shall be provided with corrosion-resistant wire cloth screening,

hardware cloth or similar material with openings having a least dimension of 1/16 inch minimum and 1/4 inch maximum. Required ventilation openings shall open directly to the outside air.

b. The minimum net free ventilating area shall be 1/150 of the area of the vented space.
    i. Exception: The minimum net free ventilation area shall be 1/300 of the vented space provided one or more of the following conditions are met:
        1. In Climate Zones 6, 7 and 8, a Class I or II vapor retarder is installed on the warm-in-winter side of the ceiling.
        2. Not less than 40 percent and not more than 50 percent of the required ventilating area is provided by ventilators located in the upper portion of the attic or rafter space. Upper ventilators shall be located not more than 3 feet below the ridge or highest point of the space, measured vertically, with the balance of the required ventilation provided by eave or cornice vents. Where the location of wall or roof framing members conflicts with the installation of upper ventilators, installation more than 3 feet below the ridge or highest point of the space shall be permitted.

5.3 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 through the walls. Dense-pack sidewall insulation must be completed wherever cost-effective (per NEAT or MHEA), including walls that separate conditioned spaces from unconditioned space, such as garages or unheated porches. There must be complete documentation in the client file giving adequate rationale whenever walls are not insulated.

Refer to NM Field Guide 9-1 and 9-2 Dense Pack a Sidewall for installation requirements.

5.3.1 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. Lead-safe work practices are required unless testing confirms it to be lead free in all pre-1978 dwellings.

5.3.2 Interior Inspection and Repairs

A. Make reasonable repairs to interior walls as needed. In pre-1978 homes, repairs to these surfaces can generate a lot of lead paint dust and debris, so lead-safe work and clean-up practices must be employed unless testing confirms the work area to be lead free.
B. 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.
C. 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.
D. Find any interior soffit areas, pocket doors or other structural details that may need preparation prior to insulating and prepare as necessary.
E. Locate critical framing juncture and ensure adequate insulation densities in these areas.

5.3.3 Exterior Inspection and Repairs

A. Note all types of siding material. Note siding material that may contain asbestos and/or lead-based paint. If the home is pre-1978, lead-safe weatherization practices must be followed unless testing confirms the work area to be lead free.
B. Determine the best drilling strategy. The preferred method is to lift the siding or temporarily remove it before drilling the sheathing.
C. Repair or replace severely deteriorated window or door components as directed by the estimate. Replace all missing glass.
D. Patch holes in exterior walls.

E. 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.
F. 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.

5.3.4 Accessing Wall Cavities

Generally, wall cavities in site-built homes are accessed from the outdoors by removing the siding with care, drilling the sheathing with an appropriate drill and bit and then inserting the proper tube to dense-pack the wall cavities with cellulose. Of course, some siding is more difficult to remove or access than others. It is always a good idea to start with the removal in a spot that is not very noticeable, such as the back of the house behind some shrubbery. If you make a mistake, it will not be as noticeable.

Here are some simple guidelines for removing and replacing different types of siding:

A. Wood clapboard siding should be removed carefully and replaced. This usually can be accomplished without damaging the siding. The sheathing should be plugged properly with wood or plastic plugs or foam insulation before the clapboards are re-installed.
B. Wood shingles or shakes must be cut with a knife at the overlap and broken off. After the wall is insulated and the holes are plugged properly, the removed shingle or shake must be re-installed in the same place and be face-nailed.
C. Board-and-batten or tongue-and-groove wood siding cannot be removed. Because of this, they must be face-drilled.
    a. Before doing this from the outdoors, the homeowner must give written permission. Horizontal rails can be place over the fill holes on the exterior walls as long as they are waterproofed properly.
    b. Rather than face-drill, the homeowner can be offered the option of installing the insulation from the interior walls. This is messy and will require some interior work to cover the fill holes, but it is usually preferable to installation from the exterior wall. Chair rails can help conceal fill holes at waist height and wallpaper

borders can conceal holes in the wall up near the ceiling. Agencies should offer their own solutions for locally-appropriate interior cosmetics within the scope of the program.

D. Vinyl siding must be unlinked carefully from the lower piece of vinyl with a zip tool and then braced upward enough with spacers to allow the drilling of the sheathing. After the insulation is installed and the holes are plugged properly, the braces are removed and the vinyl is zipped back into place with the zip tool. Take extra care when removing and replacing vinyl in cold weather, as it may crack.

E. Steel or aluminum siding usually has the same profile (shape) as vinyl, however it is much more difficult to remove aluminum and replace it without trouble, but this is an unusual skill. Many weatherization programs cut the siding just under the overhanging part with an oscillating cutter that makes a very narrow kerf (Fein MultiMaster tool is a popular manufacturer and brand). After the wall is insulated and the fill hole is plugged properly, the cut aluminum siding is face-nailed and the remaining kerf is caulked as inconspicuously as possible.

F. Asbestos siding is very brittle because it is a cement product. It is also hazardous because it contains asbestos fibers. Because of this, it should never be drilled, cut or sanded. Workers should always take precautions to wear appropriate respirators. To remove the siding, the heads of the nails are cut and/or removed with a nipper, taking care not to damage the siding. The siding is replaced by re-nailing it through the same nail holes.

G. Stucco, another cement product, is very difficult to drill.
    a. Insulation can be installed from the outdoors by drilling the stucco with a carbide- or diamond-tipped bit. If holes are drilled in the stucco, the holes must be patched so that the patch matches the color and texture of the existing stucco. This can be a challenge.
    b. Insulation can be installed from the outdoors by cutting small squares in it with a circular saw and masonry blade. The cut-out stucco squares must be replaced in the same place from which they were cut. Once the squares are cut, the sheathing below is drilled for the cellulose tube. After the cavities are dense packed with cellulose, the square cutouts are glued in place with panel adhesive.

The kerfs around each square must then be caulked with a material that matches the stucco color and texture.

c. Rather than face-drilling from the exterior, the homeowner can be offered the option of installing the insulation from the interior walls. This is messy and will require some interior work to cover the fill holes, but it is usually preferable to installation from the exterior wall. Chair rails can help conceal fill holes at waist height and wallpaper borders can conceal holes in the wall up near the ceiling. Agencies should offer their own solutions for locally-appropriate interior cosmetics within the scope of the program.

H. Brick veneer is best to insulate from the inside. Cellulose should never be installed so that it is in contact with brick or stone that is exposed to the outdoors (precipitation); there must be a moisture-proof barrier between the brick or stone and the cellulose.

5.3.5 Installation Methods for Wall Insulation

A. Wall areas above windows and doors (except in mobile homes) and the area below windows must be insulated whenever possible.

B. Uninsulated exterior walls without drywall, paneling or other interior finish material must be insulated if adding interior finish material and insulation is deemed cost-effective. If drywall is used to cover the insulation, it must be taped and mudded with one coat.

   a. If faced fiberglass batt insulation is used, it must not be left exposed in habitable areas.

C. For all enclosed walls, insulation must be installed using the tubing method rather than the nozzle method.

   a. As an exception, a nozzle may be used in small cavities such as above windows and doors.

D. Walls must be dense-packed whenever the interior wall surface material allows. Dense-packing (cellulose) requires:

   a. An insulation machine with the proper capacity (at least 80 inches of water pressure at takeoff or 2.9 pounds per square inch of pressure).

b. The proper machine settings. For dense-packing, the air-to-material ratio must be high enough for a cellulose density of at least 3.5 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.
c. Effective delivery of the insulation material from the machine to the end of the wall tube. This includes:
    i. No air leaks in the hose or at the joints.
    ii. A hose that is as short as possible for the job, but at least 50 feet.
    iii. Gradual reductions or transitions in the delivery system to minimize clogging.
    iv. A tube that is cut at an angle at the end of the facilitate insertion into the wall cavity.
d. An effective technique is:
    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 1 foot at a time as the flow in the hose and tube slows and stops due to increasing resistance in the cavity. If the tube is pulled out too soon, the density will decrease.
    iii. Inserting the tube downward through the fill hole after the wall cavity is filled upward from the fill hole. Inserting the tube with only the air running will help "drill" through the cellulose that has fallen from the upward fill. This will help achieve a higher density in the downward fill.

5.3.6 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 retains effectively the insulation material.

5.3.7 Insulation Coverage, Density and Voids

A. Sidewall insulation must be installed according to the manufacturer's recommended density and in a manner that does not allow the material to settle.

B. When insulating sidewalls with cellulose in site-built dwellings, 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. Cellulose is the preferred insulation for dense-packing walls.

C. When insulating sidewalls with blown fiberglass in site-built dwellings, install the insulation to a density of 2.2 lbs/ft^3, or per manufacturer's specification, using the tubing method, unless there is good reason not to dense-pack. If the insulation is not installed to at least 2.2 lbs/ft^3, documented reasons must be included in the client file.

D. Total voids of more than 5 percent will not be allowed by the New Mexico Energy$mart Program.

E. It may not be cost-effective 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.

F. Cellulose shall not be used to insulate mobile homes.

G. Testing to verify dense-pack to a permeance value of 3.5 cfm/ft^2 at 50 Pascals and the number of bags confirmed to match the number on the coverage chart will take place prior to the unit being reported as completed. **Refer to SWS 4.0202.1Dense Pack insulation**

5.3.8 Plugs and Patching

A. 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 (sheathing) must be patched. Various materials may be used for this patching, including wood plugs, plastic plugs or spray foam insulation.

B. Holes drilled for an interior blow are to be covered by wooden chair rail or another acceptable manner and do not need to be sealed if dense-pack of the cellulose insulation (3.5-4.5 lbs/ft^3) or fiberglass insulation (min 2.2 lbs/ft^3) is achieved.

C. Surface drilling of the finished siding and plugging the exposed drill holes is an acceptable method when methods A and B above are not practical and the client/owner approves

of this procedure in writing. Such documented approval shall be included in the client file.

D. Plugs that are compatible with the siding or wall type must be used to fill and cover the exposed surface that has been drilled.
E. Exposed plugs must be caulked and primed.
F. Any wood that is replaced as a result of the weatherization work and that is exposed to the weather must be primed.
G. 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.
H. Interior drill-and-blow techniques are preferred for homes with brick veneer siding.

5.3.9 Quality Control

A final inspection to assess quality and quantity of wall insulation must be performed. This inspection can be performed by using a bore scope, removing the interior outlet and switch plates, using an infrared camera or other acceptable inspection techniques.

5.4 Foundation and Crawlspace Insulation

This section addresses rim joist insulation, basement insulation and crawlspace insulation.

Refer to NM Field Guide 13- to 14-1 for inspection, air sealing, material and installation requirements.

5.4.1 Moisture Inspection and Repair

A. All dwellings must be inspected for problems associated with excess moisture.
B. Identification of potential moisture problems shall be documented in the client file.
C. Repair any moisture problems that will degrade or diminish the effectiveness of weatherization measures.
D. In crawlspaces with evidence of moist ground/floor, install a moisture barrier on the floor. **Refer to NM Field Guide 16-1Repair and Existing Crawlspace Vapor Barrier.**

5.4.2 Defining the Thermal Boundary

The energy auditor must decide whether the first floor or the crawlspace/foundation wall will serve at the air and thermal boundary. A lived-in basement always would be considered within the boundary, but unused basements and crawlspaces can be within or outside 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 crawlspace.

A. The crawlspace/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 or crawlspace;
    c. There are ducts and the furnace in the basement or crawlspace;
    d. Foundation walls test tighter than the floor;
    e. The basement may be occupied in the future;
    f. Laundry facilities are in the basement;
    g. Heating equipment is located in the basement;
    h. Existing crawlspace/foundation vents can be sealed without affecting combustion equipment;
    i. Floor air sealing and insulation would be very difficult; or
    j. There is a concrete basement floor.

B. The floor above the crawlspace/foundation 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. Exterior entrance only;
    d. Dirt floor or deteriorating concrete floor;
    e. Badly cracked foundation walls; or
    f. Excessive door and/or window repair is required in the basement.

5.4.3 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 the issue is resolved.

5.4.4 Rim or Band Joist Insulation

A. Insulation must be at least R-13 in climate zones 3, 4 and 5, and at least R-19 in climate zones 6 and 7; unless a NEAT audit calculation for the dwelling supports a different cost-effective level of insulation[4].
B. Fiberglass, rigid foam board, or other appropriate insulation may be used for this application.
C. If there is significant air leakage, the band or rim joist area must be sealed properly before the insulation is installed.

5.5 Floor Insulation

5.5.1 Inspection, Preparation and Repairs

Precautions must be taken to ensure adequate combustion air is being supplied through operable vents for combustion appliance in crawlspaces or basements.

A. All units must be inspected for problems associated with excess moisture.
B. If floor insulation is installed over a crawlspace area, the crawlspace floor shall be covered with a moisture barrier of 6 mil plastic when conditions warrant. This polyethylene must be lapped at least 6 inches at the joints and taped in addition to extending 6 inches up the crawlspace wall before being taped or otherwise sealed to the foundation wall.
C. Identification of potential moisture problems shall be documented in the client file.
D. Repair any moisture problems that will degrade or diminish the effectiveness of weatherization measures.
E. Repair any rotted, broken or damaged structural components when appropriate.

[4] Please refer to *2099 New Mexico Energy Conservation Code* to find climate zone designations.

5.5.2 Installation Methods for Floor Insulation

A. All appropriate air sealing of the floor should be done before insulation is installed.

B. Insulation must be a minimum of R-19 in climate zones 3 and 4, a minimum of R-30 in climate zones 5 and 6, and a minimum of R-38 in climate zone 7; unless a NEAT audit calculation for the dwelling supports a different cost-effective level of insulation[5].

C. The insulation should be installed without voids or gaps. Fit insulation tightly around cross-bracing and any obstructions.

D. Floor insulation must be fastened securely in place with wire fasteners, nylon mesh or other appropriate method. Friction fitting or stapling floor insulation is not considered an appropriate method for securing material.

    a. Floor insulation with a vapor barrier/retarder on all surfaces is acceptable (this does not replace the ground-level vapor barrier requirement).

    b. Compression of insulation must be minimized.

E. Cellulose or blown fiberglass may be used as floor insulation if they are dense-packed.

F. Do not support insulation with Tyvek, Typar or other house wrap stapled to the bottom edges of the joists. Sheet materials that allow liquid water to drain through are acceptable materials, such as InsulWeb.

G. Do not use chicken wire or other metal mesh to support floor insulation.

H. Install insulation so that it is in contact with the underside of the sub floor above.

I. Ensure that floor insulation is in direct contact with the rim or band joists. If the dwelling is balloon-framed, seal the bottom of the stud cavities prior to installing the insulation.

J. A crawlspace clearance of less than 24 inches from the bottom of the floor joists to the ground is considered inaccessible.

K. Combustible material must be kept a minimum clearance of 6 inches from any combustion appliance or flue.

[5] Please refer to *2099 New Mexico Energy Conservation Code* to find climate zone designations.

5.5.2.1 Materials

Fiberglass insulation is the preferred insulation material for a floor. New Mexico MFA recommends an encapsulated fiberglass batt or blanket for floors, such as Johns Manville ComfortTherm. This insulation is available with a vapor-barrier or non-vapor-barrier covering.

5.5.2.2 Insulation Coverage

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

5.5.2.3 Ducts and Pipes

A. When floor insulation is installed, ductwork below the floor insulation must be sealed appropriately and insulated. Please refer to Section 7.6.4 for instructions.
B. When floor insulation is installed, water pipes below the insulation must be insulated as part of the floor insulation measure. Please refer to Section 7.7.
C. 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.

5.6 Electrical Safeguards

A. Correct electrical problems such as unsafe wiring, open junction boxes or other electrical code violations prior to performing any insulation work.
B. In attics, all visible electrical junction boxes shall be covered with an appropriate junction box cover and their location must be noted on the rafter above the box.
    a. It is permissible to remove recessed light fixtures permanently with client permission if this is the most practical method of air sealing. Be certain to observe all appropriate codes.
C. Knob-and-tube wiring:

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

D. In floors, do not use any metal mesh materials, such as chicken wire, to support insulation. This can cause an electrical hazard to the installers.

6 WINDOWS AND DOORS

6.1 Primary Windows

6.1.1 Window Assessment

A. All existing egress windows must remain operable.

B. Correction of pre-existing code compliance violations is not an allowable cost except where weatherization measures are being installed.

   a. If a bedroom does not have a required existing code-compliant egress window, agencies are not required to install one only for reasons of code compliance.

   b. If a bedroom does not have a required existing code-compliant egress window and the agency intends to replace a window for reasons of saving energy, the replacement window must qualify as a code-compliant egress window.

      i. In such cases, the different between the cost of an exact type and size replacement and a qualifying egress window may be billed to health and safety.

C. Non-operable, non-egress windows may be sealed permanently against air leakage if agreed to by the client.

D. Window work on pre-1978 houses must be performed using lead-safe practices unless testing proves the work area to be lead free.

6.1.2 Window Replacements

A. Window replacements must be based primarily on an energy-saving decision process (both single- and double-glazed) rather than on client requests or aesthetics.

B. Replacement, repair or installation of a window is not an allowable health and safety cost, but may be allowed as an incidental repair or an efficiency measure if justified by the NEAT or MHEA audit.

C. When considering a window replacement for energy savings using NEAT or MHEA, "Evaluate All" is the preferred method of savings evaluation. Forcing a replacement is not allowed.

D. See NM State Plan[6] for additional guidelines on proper window assessment procedures.

E. The installation of replacement windows must meet applicable building codes.

6.1.3 Window Air Leakage

Window tightening measures such as caulking and weatherstripping should only be done if it is demonstrated that the windows are leaking and there is reason to believe that air sealing measures will be cost-effective. See NM State Plan[7] for additional guidance on proper window assessment procedures.

6.1.4 Window Repairs

A. When feasible, windows must be repaired rather than replaced.

B. Replace missing, broken or severely cracked panes.

C. Window glazing compound shall only be replaced if the existing glazing is deteriorated to the degree that the window glass is in jeopardy of falling out of the sash.

D. Refer to NM Field Guide 22-1 Window Glass Replacement for additional instructions.

6.2 Storm Windows

6.2.1 Interior Storm Windows

A. With the relative low cost of mobile home replacement windows, and the unlikelihood that a storm panel would be installed cost effectively over a good quality primary window, replacement of a substandard window generally is preferred to the installation of a storm panel.

B. If non-self-storing 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.

C. Self-storing insider storm windows can also be considered, if MHEA-justified.

D. 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.

[6] Current NM State Plan available at https://housingnm.org/home-repair-and-energy-efficiency/energymart-weatherization-assistance/learn-more/state-plans

[7] Same as above

E. A ½- to 2-inch air space between the prime window and the installed storm window is preferred.
F. Allowable storm windows include:
    a. Rigid-framed single- and double-strength glass.
    b. Rigid- and flexible-framed Plexiglas of at least 100 mils thickness.
G. Repairs to prime windows must be done to keep moisture out before an interior storm window may be installed over the prime window.
H. Storm windows must be fastened securely in place, installed straight, plumb and level and without distortion.
I. Storm windows must be installed with screws placed at least every 16 inches, including one in each corner.
J. Metal storm windows should not come in contact with frames or fasteners constructed of dissimilar metals.
K. Installed storm windows in kitchens, baths and other high-moisture areas must be operable if they provide the only source of ventilation into the space.
L. Storm windows installed above a bathtub or within 3 feet of an operable door must be Plexiglas or safety glass.
M. Operable storm windows shall move freely.

6.2.2 Exterior Storm Windows

A. 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.
B. Storm windows are to be installed so that they function properly and do not interfere with the operation of the primary window.
C. All storm windows over 32 inches in width and/ or 63 inches in height must be installed with a brace bar for stability.
D. Storm windows must be installed with screws placed at least every 16 inches, including one in each corner.
E. There must be a continuous bead of caulk sealing the storm window to the blind stop or casting without sealing the weep holes.

F. All exterior storm windows must have weep holes. If there are none, weep holes must be made.
G. 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.
H. A double-hung storm window is not to be used as a horizontal slider.
I. A double-hung storm window is not to be installed over a fixed prime window.
J. Clips used in shipping storm windows are to be removed after the storm windows are installed.

6.2.3 Other Window Treatments

Tinted window films, all sun shields and heat-reflective materials are allowed if justified by NEAT or MHEA.

6.3 Doors

6.3.1 Door Assessment

A. Doors must be assessed for needed repairs, air leaks and comfort-related problems.
B. 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.
C. Door work on pre-1978 houses must be performed using lead-safe weatherization practices, unless testing confirms the work area to be lead free.

6.3.2 Exterior Door Replacements

A. Individual replacement doors are to be run as an energy efficiency measure prior to being considered as incidental costs.
B. 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.
C. Exterior doors should be replaced with appropriate solid-core wood, insulated steel or other insulated solid-core door.

6.3.3 Door Repairs

A. When feasible, a door must be repaired rather than replaced.
B. Stuck doors need not be made operable unless they are to function as egress doors.

7 SPACE CONDITIONING

Return to Section 8.2 Heating Systems (Mobile Homes)

7.1 General Requirements

The efficient operation of heating and cooling systems is a critical aspect of efficient energy use. Replacing or repairing heating systems is allowed from an energy-efficiency or health and safety basis. Air conditioning system replacement, repair or installation is allowed in homes of at-risk occupants where climate conditions warrant (please refer to Section 7.5 for more details.) This section provides standards on the maintenance, repair, safety, efficiency improvements and replacement of existing heating and cooling appliances.

7.1.1 Space Conditioning Appliance Work Documentation

A. Each client file must include documentation of all efficiency work, adjustments or replacements made to the water heating, space heating and space cooling appliances.

B. Before the work on a combustion appliance or cooling appliance is complete, a representative of the agency must have finished a review of all combustion appliance forms and determined that the combustion appliance(s) meets the appropriate specifications.

7.2 Space Heating Appliances

7.2.1 Combustion Efficiency

Acceptable combustion analysis – post-cleaning and tuning – values are found in Table 7-1.

A. All heating systems older than one year must receive all required SWS testing, a clean, and a tune, by a licensed HVAC technician, unless it has been determined the system will be replaced.

B. Replace the heating system if the applicable conditions are met (see Section 7.4).

Table 7-1 Acceptable Combustion Test Analysis Values Post-Cleaning and Tuning

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

7.2.2 Forced Air Systems

Modifications and repairs, when possible, should meet the following specifications (applicable to type) and/or comply with the follow-up procedures. The qualified technician must document each situation in which any of the following specifications cannot be met.

A. *Gas-fired unit requirements*

a. *Gas leaks:* All identified gas leaks should be referred to appropriate persons for repair or replacement. Refer to Section 11.7.3 for gas leak testing procedures.

b. *Flexible gas lines* must be replaced when:

i. The line is badly kinked, corroded, shows signs of physical wear or enters an air handler cabinet;

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

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

c. *Cleaning and tuning:* All gas-fired units should be cleaned and tuned once every 2-3 years. Suggest the client have this service performed regularly.

B. Oil-fired unit requirements

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

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

C. *Thermostat/gas valve:* The heating system must have a thermostat in working condition that is compatible with the control circuit type (24 volt vs. millivolt). For 24-volt systems, the anticipator on the thermostat should be set equal to the measured control circuit amperage. Non-electric setback thermostats with an adjustable anticipator may be installed under the following conditions:

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

b. The client is receptive to the installation; and

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

D. *Fan on/off control:* Ideally, the fan-off temperature is between 95° and 100°F, but never below 80°F. The fan-on target range is between the fan-off temperature and 130°F, but never to exceed 140°F.

E. *Limit switch:* This switch should shut the burner off at approximately 200°F, where appropriate.

F. Blower belts and pulleys:

a. Cracked or broken blower belts shall be replaced.

b. If a larger pully is installed on a belt-drive furnace blower, the moto amperage must be measured. If the amperage draw is more than the motor's rated amperage, a smaller pully must be installed and the motor amperage measured again.

G. *Filter:* A clean furnace filter should be installed with an extra left for the client. If an extra filter is left with the client, it must be documented.

H. *Blower or air handler:* The air handler/blower should be inspected visually or physically to determine if it requires cleaning. If necessary, it should be cleaned and then motor-oiled, where applicable.

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

7.2.3 Air Handler Pressure Balance Testing

These test procedures shall be done on all central furnace systems. These tests include the whole house test procedure and the room-to-room test procedure. Refer to Section 11.3 for the details of these procedures.

7.2.4 Measurement of Furnace Heat Rise

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 restrictions in 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 must be measured on all central furnaces. Refer to Section 11.4 for testing procedure.

7.2.5 Measurement of Ductwork External Static Pressure

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.

The external static pressure must be measured on all central furnaces. Refer to Section 11.5 for testing procedure.

7.2.6 Space, Wall and Floor Furnaces

Space, wall and floor furnaces should conform to the following standards:

A. *Gas-fired unit requirements*: Please refer to Section 7.2.2 Forced Air Systems.
B. *Oil-fired unit requirements:* Please refer to Section 7.2.2 Forced Air Systems.
C. *Thermostat/gas valve*: Please refer to Section 7.2.2 Forced Air Systems.
D. *Limit Switch*: Gravity furnaces must be equipped with a working high limit switch that shuts the fuel supply off at approximately 200°F.

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

F. *Other Cleaning*: Please refer to Section 7.2.2 Forced Air Systems.

7.2.7 Mobile Home Sealed Combustion Furnaces

For the purposes of this section, a sealed-combustion furnace means a central heating unit that exhausts its combustion gases through the roof and receives its combustion supply air through the roof also, the exhaust air and supply air passing through a concentrically-arranged vent pipe.

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

A. *Gas-fired unit requirements*: Please refer to Section 7.2.2 Forced Air Systems.

B. *Oil-fired unit requirements:* Please refer to Section 7.2.2 Forced Air Systems.

C. *Thermostat/gas valve*: Please refer to Section 7.2.2 Forced Air Systems.
    a. It is preferred that mobile home thermostats be located on an interior wall.

D. *Fan-on/fan-off:* Ideally, the fan-off temperature is between 95° and 100°F, but never below 80°F. The fan-on target range is between the fan-off temperature and 130°F, but never to exceed 140°F. In addition, all appliances that are not direct-vent combustion type and have inaccessible flue pipes must have a spillage test done to verify that there is no significant spillage. Please refer to Section 11.7.6 for spillage testing details.

E. *Limit switch:* This switch should shut the burner off at approximately 200°F, where appropriate.

F. *Heat rise:* Furnace heat rise should fall within the manufacturer's recommended temperature range. If this information is not available, the heat rise should fall within a 40° to 80°F range. The furnace must not cycle on the high-limit switch. See Section 7.2.4 for heat rise information and 11.4 for testing procedure.

G. *Filter:* A clean furnace filter should be installed with an extra left for the client. No filters shall be installed on furnaces that do not have separate heat exchanger/blower compartments (International and Intertherm brands).

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

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

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

K. Steady state efficiency of sealed-combustion mobile home furnaces may be tested:
    a. From the termination of the vent on the roof, ensuring that no dilution air enters the test sample and that an accurate combustion supply air temperature is read by the combustion analyzer.
    b. By drilling the double-wall vent connector and sampling the combustion gases from the inner exhaust vent. Make sure an accurate combustion supply temperature is read by the combustion analyzer from the space between the inner and outer vents. The hole drilled through the two-pipe connector must be caulked carefully with high-temperature caulk (up to 600°F) on the inner and outer wall and taped with high-temp foil tape after testing is completed.

L. Carbon monoxide (CO) emissions of sealed combustion mobile home furnaces may be tested:
    a. From the termination of the vent on the roof, ensuring that no dilution air enters the test sample.
    b. By drilling the double-wall vent connector and sampling combustion gases from the inner exhaust vent. The hole drilled through the two-pipe connector must be caulked carefully on the inner pipe and taped on the outer pipe after the test by the final inspector.

M. Ambient CO concentrations should be measured. If any level of CO above 9 ppm is found, the source must be identified and the problem corrected.

7.3 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.

7.3.1 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 clearance meet applicable codes. Ensure that the vent system is unobstructed. Use Table 7-2 below for guidance. Refer to appropriate codes and manufacturer's instructions, if appropriate.

Table 7-2 Vent Types and Required Clearances

Return to Section 7.4.6 Solid-Fuel Heating Systems

Vent Types and Required 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. • Per Manufacturer's Instructions		

A. Mobile home combustion vents:

   a. There are no approved gas non-direct-vent furnaces for mobile homes; however, there are some non-direct-vent water heaters. They will be marked clearly "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 the 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 gases 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.

7.3.2 Appliance Clearances

Check for adequate clearance of space heaters, furnaces and flue from combustable materials. If the clearance is not sufficient, corrective action must be taken to ensure all applicable codes are followed. Refer to appropriate codes and manufacturer's instructions, if appropriate. The clearances for solid-fuel should comply with NFPA 211.

7.3.3 Combustion Supply Air for Heating Appliances

For non-direct-vent 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.

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

7.3.4 Gas and Oil Leaks

Gas leaks can be dangerous and are literally a total waste of energy. Additionally, natural gas and liquid propane (LPG) act as greenhouse gases that are as much as 20 times more potent than carbon dioxide. Check for gas leaks on all natural gas and LPG 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). Refer to Section 11.7.3 for gas leak testing procedures. If a gas leak is found, it is important to determine what side of the meter the leak has been

found. If before the pressure reducer, the gas company is to be called for repair. Any leaks found after the pressure reducer is the responsibility of the client, and not the gas company. When the leak is the responsibility of the client, the agency makes a determination of whether WAP funds can be used to remedy the problem. DOE funds can only be used when consistent with the Health and Safety Plan

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A. 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 if the leak is on the supplier side and have the problem fixed. If the leak is on the customer side, DOE funds may only be used if the H&S plan is followed.
B. Moderate gas leaks
    a. Contact the fuel supplier if the leak is on their side and have the problem fixed. If this is not possible or appropriate:
        i. Tighten the pipes and fittings (with gas supply off).
        ii. Ensure that all materials and sizes comply with NFPA and local codes.
C. All gas leaks must be fixed before weatherization work begins. Document leaks and repairs in the client file. Gas leaks on buried lines outside the house/thermal envelope are not the responsibility of the Weatherization Program, but can be repaired when feasible.
D. Oil supply lines and components must also be checked for leaks. If leaks are found, repair in accordance with NFPA and local codes.

7.3.5 Venting System Spillage

Spillage and depressurization testing must be done before and after the weatherization job is complete, since air sealing work can have an effect on proper venting. Testing at the end of each day – intermittent testing – during the weatherization work is required when measures are done that reduce natural air leakage (for example, air sealing or installation of dense-pack insulation) or may increase negative pressure within the dwelling (for example, installation of exhaust fans). Crew chiefs or final inspectors must conduct intermittent testing. With the

combustion appliance zone (CAZ) under worst-case depressurization conditions, test for spillage after one minute of burner operation on all non-direct-vented combustion appliances that have a negative pressure in their vent connectors. If spillage occurs, determine the cause and mitigate the hazard. Refer to Section 11.7.6 for spillage testing procedures.

Because approved mobile home furnaces are direct-vent, sealed-combustion units, spillage testing is not required. Direct-vent, Category III and Category IV appliances in site-built homes do not require spillage testing either.

7.3.6 Carbon Monoxide Emissions, Ambient and Flue Gas

Carbon monoxide (CO) 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 and shall be monitored at all times while in the work environment:

A. Ambient CO testing:
    a. Upon entering the job site living space, an ambient CO reading must be taken. If any level of CO above 9 ppm is found, the source must be identified and the problem corrected. (The auditor shall advise the homeowner/occupant that elevated levels of ambient CO have been detected. Windows and doors shall be opened. The auditor shall recommend that all possible sources of CO be turned off immediately. Where it appears that the source of CO is a permanently installed appliance, the auditor shall recommend that the appliance be turned off and incorporate steps for correction into the work scope, or contact a qualified professional.)
    b. An ambient air test for CO must be taken around solid-fuel appliances (if circumstances permit), unvented heaters and gas cook stove. If any level of CO above 9 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.
    d. If during any testing procedures, such as combustion safety testing, the ambient CO level becomes 35 ppm or higher, the testing shall be stopped and the area purged with fresh outdoor air. Before testing continues, the source of this CO must be mitigated.

B. In all vented combustion appliances, a CO test of undiluted flue gases must be done. If levels in the undiluted flue gas sample are above those listed on Table 11-1 for the corresponding appliance, corrective action must be taken to reduce the CO to lower acceptable levels. Record of this must be included in the client file.

C. 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 200 ppm as measured. 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. Please refer to Section 11.7.5 for testing procedures.

    a. If readings are detected above these levels:

        i. Immediately inform the client and include documentation in the client file.

        ii. Determine the source(s) and cause(s) of the problem and document reading(s).

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

        iv. Determine a plan of action based on the skill level of the crew and implement it 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 deferred and a written explanation documenting the reason inserted in the client file.

7.3.7 Combustion Safety Testing

All oil- and gas-fired furnaces, boilers and water heaters – with the exception of direct-vent units – must be tested with worst-case depressurization test procedures. Please refer to Section 11.7.6 for more information.

7.4 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 repaired cost-effectively 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 code violations. All efficiency measures must be performed and documented.

7.4.1 Replacement and Repair of Heating Systems, General

Agencies must follow the most updated Health and Safety Plan when considering units for replacement. Replacement of a heating system (furnace, boiler or space heater) is allowed when one of the following conditions exists:

A. The heat exchanger is cracked and a new one cannot be located or is cost prohibitive to install;

B. The unit is not working, displaying hazards, and is unrepairable.

The replacement of the system is justified by an analysis done with TREAT, NEAT or MHEA;

[8]

C.

D. Weatherization work causes the existing heating unit to become oversized grossly based on Manual J, NEAT or MHEA. Agencies must explore the use of non-DOE funds for replacement or buy down when this occurs.

   a. When the unit design is very inefficient or the unit is oversized grossly (justified by Manual J[9], NEAT or MHEA), resulting in high heating bills or combustion air, venting or clearances that cannot meet national, state or local codes, you must explore options through non-DOE funding to replace or buy down the unit.

   b. Sizing procedures must take into account derating for altitude. Refer to section 7.4.3 for site-built home heating system derating and Section 8.2.1 for mobile home furnace derating.

[8]

[9] The full title of Manual J is *Residential Load Calculation, 7th edition, by the Air Conditioning Contractors of America (ACCA).*

c. A grossly oversized unit can be replaced under two conditions:
    i. The existing unit will be 40 percent or more oversized based on Manual J, NEAT or MHEA post weatherization,
    ii. If an existing unit is suspected of being 40 percent or more oversized and/or has an actual input greater than 100,000 Btu/hr. Written sizing justification must be included in the client file before it can be replaced.

7.4.2 Replacement Heating System Sizing

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

A. Documentation of heating system sizing must be included in the client file.
B. Replacement heating systems should not be oversized by more than 25 percent.
C. If the calculated size is not available locally, using the next higher size appropriate for the job is permissible.
D. Sizing procedures must take into account derating for altitude.

7.4.3 High Altitude Adjustment[10]

Gas input ratings of appliances shall be used to elevations up to 2000 feet (600 m). The input ratings of appliance operating at elevations above 2000 feet (600 m) shall be REDUCED in accordance with one of the following methods:

A. At the rate of 4 percent per 1000 feet (300 m) above sea level before selecting appropriately-sized appliance.
B. As permitted by authority having jurisdiction.
C. In accordance with the manufacturer's installation instructions.

7.4.4 Heating System Replacement Efficiencies

A. Furnace replacements must have an annual fuel utilization efficiency (AFUE) of greater than 90 percent. Agencies must obtain a waiver from MFA when installing a furnace with an AFUE less than 90 percent.
B. Contact the New Mexico MFA before any boiler replacement.

[10] Based on the *National Fuel Gas Code*, NFPA 54.

C. Standalone space heater replacements must have an AFUE of at least 80 percent, except as noted below

   a. Where no practical and cost-reasonable location within the primary area to be heated is available for installation, an appliance achieving at least 80% AFUE-rated efficiency, then all attempts will be made to use the highest efficiency alternative replacement appliance possible. Any alternative appliance installed must have a minimum rate efficiency of 62% AFUE (except floor furnace at 58%). Minimum required job file documentation when installing a standalone space heater with a rated efficiency of at least 62% AFUE; (except floor furnace at 58%), but less than 80% shall be:

      i. At least one 5"x7" photograph of the condition(s).

      ii. Written description detailing the practicality or cost-reasonableness concerns associated with the particular home/condition (sufficient allowances for code-compliant exhaust venting and/or reasonable access to fuel supply lines).

7.4.5 Space Heater Replacement, Excluding Solid-Fuel Appliances[11]

A. Space heaters with low steady-state efficiencies must be replaced if justified by NEAT or MHEA. Space heaters also can 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.

   a. All efforts should be made to ensure that replacement space heaters are installed as direct-vent units. If an agency wishes to install a replacement space heater that is not a direct-vent unit, a waiver from MFA is not required, however the client file must include a brief description of why a direct-vent unit was not feasible.

B. 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 sized to heat the entire dwelling unit. If this is not possible, no weatherization work may be done. This policy is based on the fact that weatherization of the dwelling will result in

[11] See current NM State Plan available at http://www.housingnm.org/community_development/energysmart.

the probability of increased moisture and indoor air quality issues resulting from an unvented space heater.

C. New Mexico MFA 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 local codes. Funds may not be used to replace unvented secondary space heaters with unvented heaters. Funds may be used to replace unvented heaters with vented heaters, if the vented heater becomes the primary heat source. Any unvented gas- or liquid-fueled space heaters that remain in a single-family house after weatherization:

   a. Shall not have an input rating in excess of 40,000 Btu/hour;
   b. Shall 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, the situation must be documented on the Health and Safety Report and put in the client file. Client education must be provided on the limited use of the unvented space heater.

D. Agencies must submit to MFA a fuel switching request that follows the protocols outlined in the DOE Approved Fuel Switching Procedures for any fuel switch. Once

MFA approves the fuel switch on the unit, the agency may proceed with switch and follow all guidelines.

E. Electric space heaters: DOE does not allow repair, replacement or installation of stand-alone electric resistance space heaters.
F. When an unvented space heater is replaced, the old heater must be removed from the dwelling.

7.4.6 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 shall be performed before other weatherization work proceeds. The client shall be notified of any unsafe conditions.

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

A. No wood stove may be exhausted into an unlined masonry chimney. Chimney work is an allowable expense, however, if needed chimney work is not addressable with existing program funds, such wood stove configurations shall be disconnected and the chimney penetration sealed before other weatherization work can proceed.
B. The following NFPA 211 requirements must be used for all solid-fuel heating system installations. (See Table 7-2)
    a. Triple-wall or insulated double-wall vent connector pipe must be used within 2 inches of combustible materials.
    b. Double-wall vent connector pipe must be used within 18 inches of combustibles and must be kept at least 9 inches from combustibles.
    c. Single-wall vent connector pipe must be kept at least 18 inches from combustibles.
    d. If necessary, provide combustion air from outdoors to reduce negative pressure around solid-fuel appliances.
    e. Single-wall solid-fuel appliances must be kept at least 36 inches from combustibles.

f. Stoves installed closer than 36 inches to combustibles must be double-wall, or combustibles must be protected by ventilated, non-combustible wall protectors.
g. Stove clearances of less than 36 inches must be specified by manufacturer and printed on a metal tag attached to the stove.
h. For further information, refer to NFPA 211.

C. 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 spaces or other approved material.
   b. Floor protection must be:
      i. If there is at least 18 inches of open airspace between the bottom of the solid-fuel appliance and the floor, use at least 24-gauge (0.024 inch) sheet metal.
      ii. If there is between 6 and 18 inches of open airspace between the bottom of the solid-fuel appliance and the floor, the floor protection material should be ¼ inch cement board covered with 24-gauge sheet metal.
      iii. If there is less than 6 inches of open airspace 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.

D. Replacement vent connectors shall be single- or double-walled stovepipe of at least 22-gauge. Each joint must be secured with at least three sheet metal screws or equivalent fasteners with joints facing in the proper direction. Vent connector material installed in the living space of a dwelling unit must be either black or stainless steel. Galvanized vent connector shall not be used in a living space because it emits toxic zinc vapors when heated.

E. Chimneys should be cleaned mechanically 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 Energy$mart Program.

7.4.7 Solid-Fuel Appliance Replacement Policy

Return to Section 8.13 Combustion Systems (Mobile Homes)

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.

A. Replacement or repair of a solid-fuel appliance is allowed only when client health and safety is a concern. All replacements must comply with the current edition of NFPA 211.
B. There may be situations where the costs of a new installation or the repair of an existing installation may be too expensive for the Energy$mart 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 Health and Safety Report must be completed and describe each problem to be corrected. A copy must be left with the owner and a copy becomes a part of the client file.
C. Cost of repair and replacement of solid-fuel appliances are to be charged to health and safety.
D. 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.
E. 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 percent of the total material costs for the job allotted for health and safety, so careful consideration must be given to the replacement of mobile home solid-fuel appliances.

7.4.8 Subcontracting Heating System Work

Agencies using contractors for any heating system replacement are responsible for verifying and documenting that the heating system needed to be replaced, is sized for post weatherization using Manual J, that the installation complies with all national, state and local codes, and that all Energy$mart Weatherization heating system (include duct measures and standards) policies and procedures were followed. Agencies are responsible for ensuring that all mandatory health and safety testing and post-weatherization documentation is in the client file.

7.5 Space Cooling Appliances

Return to Section 7.1 General Requirements

Air conditioning system replacement, repair or installation is allowed as a health and safety cost in homes of at-risk occupants where climate conditions warrant. Otherwise, the system must rank as an energy-saving measure with an SIR above 1.0.

Air conditioning system replacement, repair, or installation is allowed in homes of at-risk occupants or where climate conditions warrant. Climate conditions that would warrant this allowance are areas that have an average of 800 CDDs or higher using a base 70. If weather data is unavailable the agency must use the weather file or data that most closely resembles the climate of the potential replacement. For other towns or areas with less than 800 CDD, medical eligibility from a third-party medical professional proving at risk is required for any occupant.

At-risk occupants are defined as an occupant that has respiratory ailments, allergies, pregnant or other unique health concerns.

In addition, service providers must request prior authorization for installation or replacement of air conditioning system as a health and safety cost.

7.5.1 Window Space Cooling Units

Replacements may justified by health and safety reason as indicated in the paragraph above, or an energy audit.

A.

B. For inspection, proceed with the recommendations below:

   a. Initial indoor inspection of room unit:

i. If connected with an extension cord, is it adequate for unit load? An extension cord cannot be more than 10 feet for a 120-volt unit and not greater than 6 feet for a 240-volt unit.
ii. Inspect service panel to insure adequate load capability for unit and dwelling.
iii. Check filter for condition. Educate client on importance of proper maintenance.
iv. Check the condition of the evaporator coil. Clean and straighten fins if necessary.
v. Check to verify that front of unit is unobstructed. It is best if the unit has 20-inches top, bottom and sides.

b. Outdoor inspection of room unit:
i. Inspect the condition of the condenser coil. Clean and straighten fins if necessary.
ii. Inspect the unit support(s) for condition, verifying permanence and air-tightness of unit in the opening.
iii. Check for proper clearances around the outside of the unit. It is best if the unit has 3 ½ feet top, bottom and sides.
iv. Verify that the condensate from the evaporator is drained properly.

7.5.2 Central Space Cooling Equipment

A. Replacements must be justified by Health and Safety reason, but must be run as an ECM first using the energy audit software and sized per Manual J cooling load calculations post weatherization. New Mexico MFA may be consulted if recommended by the audit.
B. Remove the cover of the fan compartment with the power off and visually inspect the components and cabinet condition.
C. Check all registers for condition and ease of operation. Replace as necessary.
D. Perform duct leakage tests for all approved building types and seal according to New Mexico Energy$mart Standards. Please refer to Sections 4.5, 11.6, and 7.6.2.
E. Check for proper insulation on ducts running through unconditioned areas. Seal and insulate to at least R-8, if the energy audit shows an SIR of 1 or greater.

F. In some cases, when mobile homes have central air conditioning added to the furnace ductwork, an air pressure-controlled damper is installed (sometimes just under the furnace) to regulate the flow of heated or cooled air. Occasionally this damper will stick, thereby preventing the free flow of heated or cooled air. If this happens in a client's dwelling, money may be expended to repair this cooling/heating damper.

G. For central system indoor units (evaporator coil):
    a. Replace existing filter with reusable filter and leave one extra with the client. Educate the client on how to change the filter.
    b. Check the condition of the fan for cleanliness. Clean the fan if needed.
    c. Inspect the evaporator coil for cleanliness and fin condition. Clean if necessary and straighten damaged fins.
    d. Check condition of drainage pan and drain line and to verify that they drain properly to the outdoors and away from the dwelling.
    e. Check for leaks around indoor coil and at connections.

H. For central system outdoor units (condenser coil):
    a. Inspect for cleanliness, condition and drainage and other factors that would affect performance or cause damage to the unit.
    b. Inspect insulation on suction line. Replace insulation if damaged. Visually inspect lines for crimps and leaks around fittings.
    c. Check to see that the unit has the proper clearances to allow maximum airflow around and through the unit.
    d. Check to verify that the unit is located so that it will not be damaged by client activities.
    e. Outdoor unit should be installed on a level base.

I. Unused or non-functional central air conditioning coils should be removed to increase air handler airflow.

7.5.3 Evaporative Coolers

The energy used by an evaporative cooler is only from 10 to 25 percent of the energy needed to operate a comparably-sized refrigerant air conditioner; additionally, they are much less expensive to replace.

Common types of evaporative coolers in New Mexico include single-stage (direct evaporative coolers) and two-stage (indirect/direct evaporative coolers). The single-stage type is by far the most common. The single-stage type is often classified in two additional ways, depending on the material within which water is converted to water vapor, thereby cooling the hot outdoor air before it enters the dwelling:

A. Fiber pad coolers usually use aspen wood fibers (sometimes called "Excelsior") packed in plastic netting. There are other types of synthetic fiber pads, but few perform as well as aspen. These pads should be replaced every year or two in order to maintain the efficiency of the cooler as well as air quality.
B. Rigid-sheet pad coolers use a stack of corrugated sheets that allow the water to floor the air inlet side where most of the evaporation takes place. Although these pads are more expensive than aspen pads, they also last much longer.

7.5.3.1 Weatherization Measures

A. *General Measures:*
    a. A plastic cover should be installed over the interior evaporative cooler vent. It should be installed with clips to allow easy removal and replacement. Inform the client of how to remove and replace the cover. It should be removed during the summer months.
B. *Systems with Their Own Dedicated Ductwork:*
    a. Seal ducts per Sections 7.6.2 and 7.6.3.
    b. Insulate per Section 7.6.4. Insulation shall be a minimum of R-8.
    c. Install rigid sealed covers over all register locations as nearly aligned with the primary air barrier (pressure boundary) as possible. The registers usually are in the ceiling.
    d. Deliver a homeowner's maintenance guide to evaporative coolers along with sufficient aspen pad material for replacement.
C. *Systems Sharing Ductwork with a Furnace:*
    a. Seal ducts per Sections 7.6.2 and 7.6.3.
    b. Insulate per Section 7.6.4. Insulation shall be a minimum of R-8.

c. Whenever possible, replace upper damper sealing method (installed during heating season) with an automatic damper system located as near to the furnace as possible.
d. Deliver a homeowner's maintenance guide to evaporative coolers along with sufficient aspen pad material for replacement.

7.5.3.2 Suggested Periodic Service (client education)

Evaporative coolers should be serviced periodically by a knowledgeable technician in order to maximize efficiency and lifespan. The following items are recommended:

A. Significant equipment alterations include:
    a. Install a low-voltage thermostat on coolers that have no thermostat.
    b. Replace single-speed motors with two-speed motors.
B. Service for aspen-pad coolers should be performed once each year, usually at start-up in the spring or early summer. Service items should include:
    a. Cleaning the wet section of the cooler (pump or pumps, pad, water distribution line, water pan):
        i. Remove dirt and minerals in the pump area.
        ii. Remove dirt and minerals in other wet areas of the cooler.
        iii. Inspect the pads and wash or replace as required. Slightly oversized pads are acceptable; undersized pads should never be used.
        iv. Clean the water distribution line so that water flows through it freely. If necessary, replace the line.
        v. Clean the water pump baskets. If the cooler is equipped with a purge pump, clean it also. If the water flow from the pump is inadequate after cleaning, replace the pump.
        vi. Clean the water pan at the bottom of the unit. Inspect for rust. Add a rust preventative to extend the life of the cooler.
        vii. Inspect and adjust the float valve for proper operation. Replace and adjust if necessary. Submersible pumps should have a float switch lock-out.
    b. Service of the dry section of the cooler (electrical, blower housing, blower wheel, bearings, pulleys, belts):

i. Inspect electrical connections and any controls to ensure they are safe and working properly.
ii. Check the condition of the blower housing. Look for rust and scaling.
iii. Inspect the blower wheel for wear, rust and corrosion.
iv. Lubricate all moving parts according to the manufacturer's recommendations, including use of the appropriate lubricant.
v. Pulleys should be cleaned and checked for proper alignment and smoothness.
vi. Belts should be inspected and replaced if needed. Belt tension should allow ½ to ¾-inch deflection at the center of the span when pushed with a thumb. Check the amp draw of the motor and adjust the sheave diameter and belt tension accordingly.

7.5.4 Heat Pumps

A. Upon arrival at the job site, do the following for split and packaged systems:
    a. Ask the client about any heat pump-related problems during the heating and cooling season.
    b. Ask if there is a service contract or if the unit has been serviced recently and, if so, does the client know what was done.
    c. Find out what maintenance is performed regularly by the client and how often.
    d. Determine the type of system, locate its components and note the condition of each.
    e. Remove the cover of the fan compartment with the power off and visually inspect the components and cabinet condition.
    f. Note information on the data plate regarding proper breaker size, wire gauge and lengths. Installation should conform to date plate. If not, note problems.
B. For all split system heat pump indoor units:
    a. Replace existing filter with reusable filter and leave one extra with the client if the assessor has been provided with extra filters per agency rules.
    b. Check the condition of the fan for cleanliness. Clean if needed.

c. Inspect the evaporator coil for cleanliness and fin condition. Clean if necessary and straighten damaged fins.
d. Check condition of drainage pan and drain line and to verify that they drain properly to the outdoors and away from the dwelling.
e. Check for leaks around indoor coil and at connections.

C. For all split system heat pump outdoor units:
   a. Inspect for cleanliness, condition and drainage and other factors that would affect performance or cause damage to the unit.
   b. Inspect insulation on suction line. Replace insulation if damaged. Visually inspect lines for crimps and leaks around fittings.
   c. Check to see that the unit has the proper clearances to allow maximum airflow around and through the unit.
   d. Check to verify that the unit is located so that it will not be damaged by client activities.
   e. Outdoor unit should be installed level and on a base.

D. For split system heat pumps, perform these efficiency measures:
   a. Check all registers for condition and ease of operation. Replace as necessary.
   b. Perform mobile home duct leakage tests and seal according to Energy$mart standards. Please refer to Sections 4.5, 11.6, and 7.6.2.
   c. Check for proper insulation on ducts running through unconditioned areas. Seal and insulate where necessary.

E. For packaged heat pumps:
   a. Check the condition of the fan for cleanliness. If fan needs cleaning, take amp draw and note reading. Clean the fan and retake amp draw reading to verify fan motor is in good condition.
   b. Inspect both coils for cleanliness and fin condition. Clean if necessary and straighten damaged fins.
   c. Check condition of drain pan, drain trap and drain line to verify that they drain properly to the outdoors and away from the dwelling.
   d. Visually inspect lines for crimps and leaks around fittings.

7.6 Ducted Distribution Requirements

Return to Section 5.2.15 Attic Ductwork Insulation, Section 8.9 Ductwork (Mobile Homes)

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 actually is 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 or 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.

7.6.1 Ductwork Inspection, Cleaning and Sealing

A. Ductwork must be tested and sealed according to Sections 4.5 and 11.6.
B. Existing flex duct must be supported adequately without sags. Additional support is often needed.
C. Delivery and return ductwork must be cleaned as necessary to remove large objects and debris that may impede airflow through the heating system.
D. Uncover any blocked registers or grilles. Explain to the client the importance of maintaining the unrestricted airflow.
E. As necessary, supply registers and return air grilles must be removed and cleaned to remove excessive dirt and debris that may impede airflow.
F. When appropriate, remove and block off ducts, registers and grilles located in unconditioned spaces.
G. Ductwork outside the thermal envelope of the dwelling must be sealed with mastic and insulated (where accessible).
H. All accessible return air ductwork within a combustion appliance zone (CAZ), except gravity systems, must be sealed enough to eliminate the potential for backdrafting.
I. 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.
J. Existing crawlspaces used as plenums should be abandoned and replaced with a sealed duct system (where accessible).

7.6.2 Duct Sealing

Return to Section 8.9 Ductwork (Mobile Homes)

Gaps larger than ¼ inch between the air handler and adjoining ductwork or equipment will be bridged with sheet metal.

A. **Refer to NM Field Guide 19-1 Seal Ducts with Mastic for additional instruction.**

B. Accessible duct joints, cracks, seams, holes and penetrations shall be sealed as specified below:
    a. Surfaces will be cleaned properly before sealing.
    b. Seams, cracks, holes and penetrations less than ¼-inch will be sealed using fiberglass mesh and mastic.
    c. Seams, crack, holes and penetrations between ¼ and ¾ inch will be sealed in two stages:
        i. They will be backed using temporary tape – foil tape – as a support prior to sealing;
        ii. They will be sealed using fiberglass mesh and mastic. Fiberglass mesh and mastic shall overlap the temporary tape by at least 1 inch on all sides.
    d. Seams, crack, holes and penetrations larger than ¾ inch shall be repaired using rigid duct material.
        i. Fiberglass mesh and mastic shall overlap the repair joint by at least 1 inch on all sides.

C. Installation of mastic will be applied in a manner that meets manufacturer specifications, as well as UL 181M, NFPA 90A and NFPA 90B.

D. In mobile homes, if the boot is loose to the floor, it shall be reattached to the subfloor with roofing nails, staples or wood screws. Ensure that the heads of 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.

7.6.3 Duct Sealing Materials

Return to Section 8.9 Ductwork (Mobile Homes)

A. Cloth duct tape shall never be used for duct sealing.
B. Existing duct tape must be removed before installing duct mastic or other approved sealing materials.
C. Mastic shall meet the following requirements:
    a. Non-toxic and water-resistant.
    b. UL listed and labeled per UL 181A and 181B standards.
    c. Shall be compatible with the duct material to which it is applied.
D. Mesh fabric used to reinforce duct mastic shall meet the following requirements:
    a. Comply with the mastic manufacturer's specification.
    b. Made of fiberglass.
    c. Have at least a 9x9 weave per inch.
    d. Be at least 0.006 inches in thickness.
E. For flexible ductwork:
    a. UL 181BM 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.
F. Ducts shall be fastened properly 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 to duct board joints will be fastened with a stitch stapler.
    d. Duct board to flexible duct joints will be fastened with a metal take-off collar.
    e. Metal plenum to air handler cabinet joint will be fastened with a minimum of three equally-spaced sheet metal screws.
    f. Flexible duct, duct-board and metal ducts shall be supported every 4 feet using at least a 1½-inch material.

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

7.6.4 Ductwork Insulation

Return to Section 5.5.2.3 Ducts and Pipes

A. Active ductwork outside the thermal envelope 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.
B. Supply and return ducts and plenums located within the thermal/pressure envelope do not require thermal insulation.
    a. Exception: There might be cases where insulation is appropriate within the thermal envelope, 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 open fully.
        iii. The branch duct air leakage has been checked and sealed, if necessary.
C. Combustion vents should not be insulated.
D. Insulation must have a flame-spread rating (no greater than 25).
E. It is best to use vinyl-backed, reinforced foil duct wrap or two-part foam on ducts.
F. 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.
G. Do not wrap duct insulation so tightly that it is compressed. It should not be compressed more than 50 percent of normal thickness.
H. Maintain proper clearance between duct insulation and combustion appliance flues.

I. Install protective covering around the insulation where required by local regulations.

J. Ducts with existing asbestos insulation must not be disturbed.

7.6.5 New Ductwork Installations

A. New ductwork should not be installed unless absolutely necessary for proper functioning of appliance and distribution system.

B. 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.

C. Attempt to install all new ductwork within the thermal/pressure envelope.

D. Do not install ductwork within exterior walls.

E. Building frame cavities, closets, crawlspaces and chases must not be used as ducts. However, ductwork may be housed by or passed through these spaces.

F. Ductwork must be installed at least 4 inches from any bare earth.

G. New ductwork installations may not include panned joists or stud cavities for ducts. Al passageways for distribution air must be hard-ducted; panned floor joists may not be used.

H. A crawlspace may not serve as a distribution plenum.

I. Do not use a dropped-ceiling cavity as a plenum.

J. 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. Flex duct must be supported according to manufacturer's specifications.

   b. Flex duct must be supported according to manufacturer's specification. 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.

Pressure pan testing must be done in some dwellings to determine if new ducts installed outside the thermal/pressure envelope are leaking to or from the outdoors. Refer to Section 7.6.6 below for more information.

7.6.6 Duct Leakage in Site-Built Homes

A. New Mexico 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.

B. For ducts located outside of the pressure envelope:
    a. If possible, convert the space where the ducts are located to a conditioned space, making sure the pressure and thermal barriers are installed effectively.
        i. Demonstrate the effectiveness of this weatherization work by performing a house-to-zone pressure and flow test (if possible) before and after converting the space to a conditioned space.
        ii. Always repair disconnected ducts in the space.
        iii. It is preferred to seal the pressure envelope of the space rather than sealing the duct joints.
    b. If the duct-containing 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 for mobile homes and to determine the ducts with the highest leakage outside of the pressure envelope. Refer to Section 11.6.2 for instructions.
        ii. Subtraction method is required for site-built homes. Section 11.6.1 for instructions
        iii. Repair, seal ducts with mastic and thermally insulate ducts in unconditioned space to at least an R-8.

C. For ducts located within the thermal/pressure envelope, such as a basement:
    a. Always repair disconnected ducts or ducts that are leaking significantly. Adhere to combustion safety testing recommended above in A and A.a.
    b. Visually inspect the conditioned space to ensure that the thermal/pressure envelope is treated properly.

c. If it is determined that weatherization work should be done to the pressure envelope of the conditioned space housing the ducts, perform a house-to-zone pressure and flow test (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 crawlspace is opened to the outdoors.
    iii. Pressure pan testing at registers and grilles while the blower door is operating and the basement or crawlspace is opened to the outdoors.

7.6.7 Duct Leakage Standards, Mobile Homes and Double-Wides

Return to Section 4.5 Duct Leakage

A. 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 8.9, B. Belly Return Conversions.
B. Inspect the duct work visually. Then seal all penetrations in the duct trunk line and boots and seal the ends of the duct run.
C. When the above duct sealing work is completed, conduct a pressure pan test on all duct registers, including the furnace plenum.
D. If the furnace plenum is accessible, it must be sealed.
E. 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.
F. If the sum of the pressure pan 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.
G. 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 as possible.

H. A duct blower may be used to test the duct work. If this procedure is used, the take may be considered complete if the CFM leakage to the outside when measured at 25 Pa is less than 10 percent of the total floor space. For example, if a mobile home is 14 feet by 66 feet, the area would be 924 square feet. The duct blower reading must be less than 10 percent of the floor area of 924, or 92.4 CFM_{25}.

7.7 Piped Distribution Requirements

Return to Section 5.5.2.3 Ducts and Pipes

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

7.7.1 Steam and Hot Water Heat Distribution Pipes

A. Make certain there are no leaks in hot water distribution pipes.
B. Supply and return lines in spaces outside of the thermal envelope must be insulated if they are accessible.
C. Pipes may be insulated within the habitable space if it is determined that the space does not require heating or is overheated.
D. Pipe insulation must be sized to the pipe being insulated.
E. Secure the pipe insulation with mechanical fasteners or appropriate tape.
F. Pipe insulation must have mitered cuts at corner joints. Tape joints appropriately.
G. Pumps, valves, pressure relief devices or vents should not be insulated. Do not insulate over heat tape.
H. Closed cell foam, high temperature rated insulation or elastomeric pipe insulation should be used that has a flame spread rating no greater than 25.
I. Maintain the manufacturer's recommended clearance between pipe insulation and combustion appliance flues.

8 MOBILE HOME REQUIREMENTS

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

8.1 General Inspection

An auditor will perform an inspection of the mobile home, gathering the following information and testing:

A. Relevant dimensions of the dwelling;
B. Health and safety issues;
C. Existing R-values and cavity depths;
D. Structure soundness; (examples – unstable, improperly joined double-wide, walls or floor cannot support weight adequately)
E. Air leakage;
F. Indoor air quality and installation of smoke and CO detectors, where applicable;
G. Moisture problems;
H. Ventilation systems;
I. Heating appliance(s) efficiency;
J. Cooling appliance(s) efficiency; and
K. Client equipment-use problems (e.g., water heater not Mobile Home approved).

Upon completion of the inspection and tests, the auditor will develop a work scope by using MHEA or another acceptable computer energy auditing tool. If it is determined that measures should be completed in an order other than those listed by MHEA, for health and safety or other reasons, it must be documented in the client file.

8.2 Heating Systems

Satisfy all requirements of Section 7 Space Conditioning.

8.2.1 High Altitude Adjustment[12]

Return to Section 7.4.1 Replacement and Repair of Heating Systems, General

A. If a mobile home is relocated to a site with an altitude greater than 2000 feet above its previous location, its furnace must be derated (by a properly licensed professional) at a rate of 4 percent per 1,000 feet. This is because there is less oxygen at higher altitudes, so fuel-rich combustion results if the burners are not derated, reducing the gas flow. For example, if a mobile home furnace is near sea level and it is relocated to 3,000 feet, its burners must be derated by 12 percent.
B. Consult with the manufacturer (as necessary) before any derating is done. Derating is accomplished by installing a smaller orifice in each burner typically.
C. Some Category I, fan-assisted furnaces do not require derating because the induced-combustion fan is able to supply enough oxygen-depleted air to allow the combustion to take place at the proper fuel/oxygen ratio. Check with the manufacturer.

8.3 Moisture Problems

A. If there are moisture problems in the ceiling or sidewalls, insulation should not be added until moisture source and/or site of penetration, including leaks, is identified and eliminated. Refer to Section 3.7 for more information. Identify if there are pressures that exacerbate moisture problems and find a solution to the problem.
B. Exhaust fan ducts terminating in ceiling cavities, crawlspaces or other areas shall be extended to the outdoors and sealed to prevent exhaust air from re-entering the conditioned space.
C. Dryer vents shall be vented to the outdoors. If the mobile home is skirted, the dryer vent termination must be to the outdoor side of the skirting. Refer to NFPA for additional details.

8.4 Electrical Inspections

The electrical wiring in pre-1978 manufactured homes is sometimes aluminum. This aluminum wire, when in contact with other metals that are common in electrical systems, can cause

[12] Based on the *National Fuel Gas Code,* NFPA 54.

galvanic corrosion and shorting. As a result of this possibility, in pre-1978 manufactured units special care should be taken.

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

8.5 Air Leakage Reduction Requirements

A. Perform initial blower door test before any work is done to the mobile home. Repair any obvious major leaks, utilizing the blower door to direct efforts.
B. Refer to Section 4 for Air Sealing Guidelines.
C. In mobile homes, concentrate on the following air sealing areas:
    a. Ductwork sealing.
    b. Insulation preparation work and insulation installation.
    c. Major repairs to the air barrier and thermal boundary.
    d. Air sealing work that is necessary to block moisture migration into ceilings and walls.
D. In addition to the leakage areas noted in C above, major air leaks should be addressed first, including:
    a. The plumbing chase behind the washer and dryer,
    b. The water heater closet,
    c. Under the bath tub, and
    d. Around the electric service entrance conductor.

E. Air leak mitigation measures that enhance client comfort (e.g., installing a storm window near a reading chair or installing a jamb weatherstrip kit on a door near a reading chair) must be documented with a brief explanation in the client file.
F. Weatherstripping and/or drip caps shall be used whenever possible to reduce air and/or water leaks around primary windows.
G. When accessible, the joint (marriage wall) between the two sections of a double-wide must be filled and sealed from underneath the structure. When it is not possible to seal from the exterior, interior trim should be removed and the leaks should be sealed from the interior. This leakage commonly is found in archways and doors in the center of the double-wide dwelling.
H. 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. If the gas water heater is a Category I, natural draft unit, the wall between the water heater and the interior of the dwelling must be sealed.
I. Continue air sealing until it is no longer cost-effective.

8.6 General Insulation

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

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

8.7 Ceiling Insulation

A. The ceiling and roof condition must be inspected and assessed before installing insulation.
B. If it is cost-effective, ceilings that appear weak shall be repaired and reinforced – especially in heavy snow load areas – before installing insulation.
C. Recessed lighting fixtures and fan/light combinations that are Type IC (insulation contact) rated by UL may be covered with insulation. Thermal insulation shall not be

installed within 3 inches of fan/light fixtures or recessed light fixtures that are not rated Type IC.

D. Ventilation fan (not fan/light combination) housings and ducts may be covered with insulation if all holes and penetrations are sealed with a nonflammable sealant. Fans must remain operational.

E. All mobile home flues and chimneys must be listed for use in mobile homes to assure adequate clearances are maintained.

F. Blocking around combustion appliance vents is required when insulation is installed, except where combustion air is pulled through a pipe that surrounds the combustion appliance vent pipe (concentric pipe system). Follow the manufacturer's recommendation for clearances between vents and combustible insulation. Air seal around vents following the manufacturer's specifications.

G. Ceiling insulation must be fiberglass and installed in a manner that ensures complete coverage over heated or cooled areas. Ceiling cavities should be blown to a density of 0.8-1.0 pounds per cubic foot (approximately R-3.5 per inch). It is useful to use a bag-count method to determine the total amount of insulation to install.

H. Mobile home ceilings shall not be insulated with cellulose or over-filled with loose fiberglass so as to create structural problems in the ceiling.

I. 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 roof. If such venting is left in place, it effectively short circuits the added insulation between the original and added framed roofs.

J. If an interior fiberglass drill-and-blow method is used for installing insulation, holes must be plugged and sealed properly. The holes must be straight and equidistant. In addition, there must be an access hole in each cavity to ensure complete coverage. In most mobile homes, two access holes per cavity are preferred for a more even coverage.

K. If an exterior or side-opening (edge lift) installation method is used, all roof penetrations and areas of potential leakage must be sealed with elastomeric sealant (when compatible with roof materials) or another equivalent sealant, as necessary. Areas that are to be patched must be cleaned first, down to the metal roof surface. After insulation, reattach

existing gutters with screws that are one size larger than the original screws. The edge lift method is the preferred method to insulate 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 recommended rather than walking on the roof itself.

L. Installing insulation from the ridge of the roof is allowed.

M. 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 are not allowable methods for access. If this method is used, the reason for not using the methods listing in K and L above must be documented in the client file.

N. 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.

8.8 Sidewall Insulation

8.8.1 Sidewall Insulation Requirements

A. Mobile home sidewalls should be insulated when the MHEA Recommended Measures Report shows it is cost-effective.

B. If the wall insulation thickness is less than the cavity depth, the apparent R-value must be reduced by at least 25 percent. The R-value may be decreased by more than 25 percent if the installation is of very poor quality and does not come in contact with all six sides of the cavity. If the R-value is reduced by more than 25 percent, the reason must be documented in the client file.

C. The exterior siding and the interior wall materials must be inspected prior to the installation of insulation.

D. Weak or damaged wall materials must be repaired or reinforced prior to installing insulation. Pictures and other items hanging from the walls must be removed before installing the insulation.

E. Installing insulation above windows and doors usually is not feasible or cost-effective and is not required in mobile homes.

8.8.2 Sidewall Insulation Methods

A. Vinyl-faced fiberglass batt insulation (batt-stuff method) and loose-fill fiberglass are the preferred insulation materials for mobile home sidewalls. Select the method that will take the least amount of time to install. If it is important to install a vapor barrier, use the batt-stuff method.

B. For cavities that cannot or should not be insulated with the batt-stuff technique, the fill-tube method with loose-fill fiberglass is recommended.

8.9 Ductwork

Return to Section 7.6.7 Duct Leakage Standards, Mobile Homes and Double-Wides

A. General:

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

b. Visually inspect registers, boots and the trunk where there is any evidence of air leakage or blockage.

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. See Sections 7.6.2 and 7.6.3.

e. Inspect, test and repair, if necessary, the connection between the furnace plenum and the main duct run.

f. Trunk-end stops are necessary only if it is determined that the installation will reduce duct air leakage.

i. End stops shall be made from sheet metal or aluminum valley flashing 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 4 inches. Gaps between the stop and the duct must be sealed with mastic.

ii. It is allowed to block the end of the trunk with polyethylene-encased fiberglass. This plug should be placed a minimum of 12 inches beyond the register opening to help ensure proper back pressure. Seal the plug to the duct surfaces with mastic to ensure no air leakage remains. Use a pressure pan test to verify an air-tight seal.

g. Closable registers with vanes are not recommended. Existing closable registers should 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 fastened mechanically to the floor except for situations where they may become a tripping hazard to the client.

j. Please refer to Section 7.6 Ducted Distribution Requirements for more information. Also refer to Section 11.6 for duct leakage testing procedures.

B. Belly Return Conversions:

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

i. Installing adequately-sized return air grille(s) in the furnace closet door;

ii. Sealing the return grilles in the floors of bedrooms, bathrooms, kitchen, living area, etc.;

iii. Sealing the return air grille in the furnace closet floor; and

iv. Undercutting doors, adding door or wall registers or installing jump registers in the attic in a manner that reduces the room-to-room pressure difference (with the door closed and the air handler operating) to 3 Pascals or less.

b. For a discussion of duct leakage measurements and standards, follow the instruction in Section 4.5.

c. For ductwork sealing and insulation, follow the instruction in Section 4.5.

C. Crossover duct repair and treatment:

a. Crossover ducts shall 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 shall

be protected against rodents, pets, etc., and suspended above the ground properly. If replacement is needed, replace with rigid duct and insulate to R-8.

b. Flexible crossover ducts shall have a minimum R-8 insulation. They shall be secured with mechanical fasteners (e.g., 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 4 or less which has been damaged may be replaced with new foil-faced flexible duct with R-8 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.
e. Crossover ductwork must be secured appropriately above the ground. It may be supported by strapping or blocking.
f. Flexible duct shall not be allowed to sag more than 12 inches over a span of 8 feet.
g. Flexible duct must be foil-faced since it is located in an unconditioned space.

8.10 Floor (Belly) Insulation

A. 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. It is best practice to explore using non-DOE funds to make belly rodent barrier repairs even if no 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, the R-value of existing insulation and the cavity depth.

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). Leaks should be fixed prior to weatherization.

e. Belly insulation shall be installed only after all repairs have been made, major holes in the rodent barrier and floor have been sealed and all ductwork has been sealed according to Section 4.5.

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 or one section using material that meets applicable fire safety code and creates a continuous insulation layer. These must adequately support applied load and are permanent air barriers. See SWS 3.0102.7 for specs.

h. Draped belly areas shall not be dense-packed or over-filled so as to create undue stress on the belly rodent barrier.

B. Floor Insulation Methods:

a. Loose-fill fiberglass shall be the insulation material for mobile home bellies.

b. Bellies that hang 8 inches or less below the floor in the center area should be filled entirely with insulation blown at the required densities.

c. Bellies that are greater than 8 inches below the floor at the center area should be insulated using the perimeter method. If possible, leave space between water pipes and the floor to reduce the likelihood of frozen pipes.

d. A recommended 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 to 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.

e. When belly insulation is to be installed from underneath the home, then a ground barrier (compliant with SWS 2.0403.4) MUST be installed before insulation work commences whenever any of the conditions listed below are present.
    i. Evident ground moisture
    ii. Any health and safety hazard that may be remedied through use of a barrier
    iii. Any condition that is not severe enough to require deferral.
f. If none of the above conditions is present, then a ground barrier MAY be installed as optional additional crew protection.
g. 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.
h. Insulated sheathing board, fiberboard and nylon-reinforced belly bottom material specifically manufactured for mobile homes are the preferred patching materials for large holes in the belly rodent barrier. Soft patching materials that may be used include Tyvek and Typar. Patches should be adhered with silicon or other durable adhesive and then stapled with stitch staples.
i. Ductwork must be inspected for insulation that accidentally might have been installed inside the ductwork during insulation work.
j. Upon completing insulation work, rim joists that have been drilled shall be plugged with an appropriate plug. The plug shall be sealed in the hole with an adhesive compound.

8.11 Insulation of Water Supply Systems

A. Water pipes that have not been protected from freezing with under-floor insulation should be insulated to a minimum of R-3.
B. The piping shall be free from water leaks and secured properly to support the weight of the piping and insulation.

C. 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 shall 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.

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

8.12 Water Heaters and Their Closets

A. 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, unless not allowed per manufacturer. Please refer to Section 9.1.4 for instructions.

      i. Large holes in the closet walls that allow air leakage into the interior living area must be sealed.

      ii. All plumbing within the closet that is susceptible to freezing must be insulated.

      An adequate amount of combustion air must be provided to gas water heaters.

      iii.

B. 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.

C. Insulate the first six feet of cold and hot water pipes to/from the hot water tank. Insulate any other cold-water pipe exposed to freezing temperatures. Maintain clearances from combustible pipe insulation with gas water heaters.

D. 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.

E. Install low-flow showerheads whenever possible and cost-effective.

8.13 Combustion Systems

A. If interior combustion air is used for the furnace, it must be replaced with a sealed combustion (direct-vent) furnace.

B. All fuel-burning, heat-producing appliances in mobile homes, except ranges and ovens, must be vented to outside. Further, all fuel-burning appliances in mobile homes, except ranges, ovens, illuminating appliances, clothes dryers, existing solid-fuel-burning fireplaces and existing solid-fuel-burning fireplace stoves, must be installed to provide for the complete separation of the combustion system from the interior atmosphere of the manufacturer home (i.e., to draw their combustion air from outdoors).

C. For replacement of solid-fuel-burning appliances, please refer to Section 7.4.7.

8.14 Inside Storm Window Installation

A. The MHEA should be used to justify installation.

B. 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 energy auditor is assured by the client that they will maintain and reinstall panels correctly.

C. Self-storing inside storm windows are preferred and can be considered if MHEA justified.

9 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.

9.1 Water Heaters

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

9.1.1 Water Heater Inspection

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

A. All identified gas leaks should be repaired by the responsible party using a licensed HVAC professional. If the leak is on the house side of the meter or the side where the gas supply enters the meter, it is the homeowner/subgrantee's responsibility. If the leak is between the meter and the street, it is a job for the gas company. All gas leaks should be documented in the client file. Refer to Section 11.7.3 for gas leak testing procedures.

B. All water heaters must be vented properly.

C. All fossil-fuel water heaters, with the exception of direct-vent units, must be tested with worst-case depressurization test procedures (See Section 11.7).

D. All gas-fired direct-vent (sealed-combustion) and atmospheric combustion water heaters must be tested for carbon monoxide emissions. Measured CO levels must be equal to or less than 100 ppm air-free.

E. All water heaters must have a water temperature test.

F. 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.

G. Inspect the temperature & pressure relief (T&P) valve to determine if it is installed correctly.

9.1.2 Domestic Hot Water Pipes- NM Field Guide 23-3 Insulate Domestic Hot Water (DHW) Pipes

A. Make certain there are no leaks in domestic hot water pipes.

B. Closed-cell foam, high-temperature rated insulation or elastomeric pipe insulation should be used that has a flame spread rating no greater than 25.

C. Maintain a minimum of 6 inches between pipe insulation and all heat sources.

D. Domestic hot water pipes running through unconditioned spaces must be insulated if accessible.

9.1.3 Water Heater Replacement and Installation

A. Water heater replacements must be run as an energy efficiency measure prior to being considered as a health and safety measure.

B. Accepted industry procedures and practices will be followed for water heater removal and replacement.

C. Replacement electric water heaters must have an energy factor of at least 0.93. Replacement gas heaters must have an energy factor of at least 0.81 UEF (medium draw pattern) or 0.86 (high draw pattern), for all tanks sized between 20-55 gallons.

D. An emergency drain pan will be installed.. A ¾-inch drain line, or larger, will be connected to tap on the drain pan and run to a drain or pumped to daylight.

E. A steel bladder expansion tank will be installed on the cold-water side (as required by applicable code).

F. Temperature and pressure relief (T&P) valve, dielectric unions and backflow prevention will be installed according to the manufacturer's specifications.

G. The following will be checked once the new system has been filled and purged:

   a. Safety controls.
   b. Combustion safety and efficiency.
   c. Operational controls.
   d. Fuel and water leaks.
   e. Local code requirements.

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

a. Adjustment of water heater temperature.
b. Periodic drain and flush.
c. Expansion tank and backflow preventer (no occupant maintenance required).
d. Periodic inspection.

9.1.4 Water Heater Blankets

Return to Section 8.12 Water Heaters and Their Closets (Mobile Homes)

The installation of water heater blankets on gas-fired and electric water heaters in conditioned spaces is recommended unless this will void the water heater warranty. The top of gas water heater tanks should not be insulated.

9.1.5 Water Heater Blanket Materials and Installation

A. Refer to **NM Field Guide 23-1 and 23-2 Insulate Domestic Hot Water Heaters.**

B. A water heater blanket must not be installed when a temperature and pressure relief (T&P) valve does not exist or when the existing T&P valve does not operate properly.

9.1.6 Domestic Hot Water Temperature

In order to prevent scalding of occupants and users, water heaters should be set to deliver hot water at 120°F at the faucets and showerheads. **SWS 7.0302.2m Discharge Temperature Settings.**

9.1.7 Energy-Saving Showerheads

A. An energy-saving (low-flow) showerhead may be installed with client permission, if the replacement is possible and cost-effective and the installation does not require the use of a plumber.

B. The energy-saving showerhead must have a flow rating of 1.5 GPM or less. If multiple showerheads are provided for one shower unit, the total flow rate shall not exceed 3.5 GPM.

C. IF an energy-saving showerhead is installed in conjunction with lowering the domestic hot water temperature, the chances are high that the client will not notice less hot water for showering, as they might if the temperature is reduced without installing the new showerhead.

D. Removed showerheads may be left with the client at their request.

E. The occupant's acceptance or refusal of a showerhead must be documented.

9.1.8 Faucet Aerators

A. Measure aerator flow rate. Aerators may be replaced if flow rate is more than 2.2GPM.

B. The occupant's acceptance or refusal of aerators must be documented.

9.2 Gas-Fired Cooking Ranges

Gas ranges shall be inspected and tested according to Section 11.7.5. Appropriate client education shall be delivered to an adult client in the household.

9.3 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; however, the client must provide the agency with written permission for this disposal.

9.3.1 Refrigerator Replacement Policy

A. Refrigerator replacements must meet DOE requirements[13]; if applicable, the corresponding requirements of non-DOE funding, such as the local electric utility, may be used.

B. The replacement refrigerator must be cost-effective. If the savings-to-investment ratio (SIR) is less than 1, no replacement is allowed. The SIR 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 of as part of the refrigerator replacement.

[13] See current NM State Plan available at https://housingnm.org/home-repair-and-energy-efficiency/energymart-weatherization-assistance/learn-more/state-plans.

C. The client must give up possession of the old refrigerator.

D. All refrigerators that are replaced must be removed from the clients' premises upon delivery of the replacement and disposed of properly in accordance with The Clean Air Act, USC Title 42, Section 7671g. This Act makes it unlawful for any person to dispose of refrigerants in a manner in which they will be allowed to enter the atmosphere.

E. The replacement refrigerator must be ENERGY STAR®-rated with an estimated annual consumption of 600 kWh/yr or less. It must be a similar style and capacity to the one being replaced, with 17-18 cubic feet being average size. Refrigerators with options such as an ice maker will not be considered allowable replacements.

F. The NEAT/MHEA tool can be used to calculate savings-to-investment ratio (SIR) and to provide documentation that the replacement SIR is greater than 1.0. NEAT can calculate the SIR of a refrigerator replacement in three 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[14]. On-site metering is the preferred method of determining energy use, unless metering is not possible.

   c. DOE's Refrigerator and Freezer Energy Rating Database Search Tool.

G. 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.

9.3.2 Refrigerator Metering

A. Use a cumulative Watt-hour meter to determine the present usage of the refrigerator. Meter for at least two hours. The longer the metering time, the more accurate the project annual kWh/yr estimate will be.

B. When metering, it is vital that the inspector determine with the metering instrument if the refrigerator has defrosted automatically during the metering time. If so, the metered

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values must be adjusted downward by 8 percent. Both NEAT and MHEA have check boxes to select if the defrost cycle is included in the metering.

C. Determine the average ambient temperature around the refrigerator during the metering and enter into NEAT ("Temperature F").
D. Convert the Watt-hour reading on the meter to kilowatt hours (kWh) by dividing the Watt-hour reading by 1000. Enter the resulting value in the appropriate place in NEAT. For example, if the Watt-hour reading is 525, the kWh value entered into NEAT is 525/1000, or 0.525.
E. Enter the time period of the metering in NEAT. Make sure the time is in units of minutes.

9.3.3 Ordering Replacement Refrigerators

A. 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 (and freezers) are being replaced.
B. WAP grant funds cannot be used to run water line for an ice maker.
C. Each agency is responsible for ordering appropriate ENERGY STAR® refrigerators either directly or by subcontracting.
D. Each agency is also responsible for proper disposal of all refrigerators either directly or by subcontracting.

9.3.4 Installation of Replacement Refrigerator

A. The replacement must fit into the existing refrigerator space and must have the hinges installed on the appropriate side.
B. The installer should ensure that the doors and hallways of the home are sufficient to allow removal of the old refrigerator and installation of the new one.
C. The installer should ensure that there is safe and adequate electrical supply and that the floor is adequate structurally to support the new unit.

9.4 Lighting

9.4.1 Introduction

Many new light-emitting diode lamps (LEDs) meet the stringent criteria of ENERGY STAR® for long life, start time, energy savings, color and brightness. These new LEDs provide high-quality, warm light without the excess heat produced by older incandescent and halogen bulbs.

Advanced technology enables LEDs to use over 80 percent less energy than a standard incandescent bulb and last 15-20 times longer. This means that over the life of one LED, a client can avoid replacing up to 20 incandescent bulbs while saving on energy costs as well.

New Mexico has received approval to use LED replacements for residential homes as long as the bulb is proven to be cost-effective with a savings-to-investment ratio (SIR) of 1.0 or greater. All bulbs, fixtures, and controls must be ENERGY STAR® rated and in accordance with SWS 7.0103 Lighting

9.4.2 Replacement Procedure

A. All replacement LEDs must be ENERGY STAR® rated.
B. 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 LEDs.
C. Ensure that replacement LEDs are the appropriate type for replacing outdoors or in lamps and fixtures with dimmers.
D. Any replacement LEDs should have a lumen rating (light output) very close to the replaced incandescent lamp. If the Watt use of typical LEDs and incandescent lamps are matched according to Table 9-1, the lumens output approximately will be the same.
E. Replacement LEDs should be rated 2700 to 3000 Kelvin. This color index is similar to incandescent bulbs.

Table 9-1 LED/Incandescent Lamp Equivalency Chart

LED/Incandescent Lamp Equivalency Chart		
LED	**Incandescent**	**Lumens**
6 – 9 W	40 W	450 lm
8 – 12 W	60 W	800 lm
9 – 13 W	75 W	1100 lm
16 – 20 W	100 W	1600 lm
25 – 28 W	150 W	2600 lm

10 MULTIFAMILY BUILDING WEATHERIZATION

For energy auditing purposes, DOE considers multifamily buildings to be those containing five dwelling units or more. Approved single-family energy audits, such as NEAT, may be used in buildings with one to four dwelling units. NEAT may be used on some multifamily buildings up to 25 *individually* heated/cooled dwelling units with approval from DOE on a case-by-case basis.

For small multifamily buildings of 25 or fewer dwelling units containing central heating/cooling systems, as well as larger multifamily buildings greater than 25 dwelling units regardless of heating/cooling systems, NEAT may not be used. In the past DOE has reviewed and accepted the use of EA-Quip or TREAT as permissible energy audits.

10.1 Multifamily Building Differences

The energy-savings options 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:

A. Who is the client? The tenant or the owner?
B. Who must apply for weatherization services?
C. Who pays for the utilities? The owner or the tenant?
D. Is there a building manager?
E. Who will decide what measure are implemented?

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

A. The heating systems typically 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.

B. 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.

C. Envelope 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.

D. Mechanical ventilation should be analyzed for effectiveness and savings.
    a. Follow ASHRAE 62.2-2016 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.

E. Baseload
    a. Replace refrigerators.
    b. Indoor and outdoor lighting change out and controls.

11 DIAGNOSTIC TESTING PROCEDURES

11.1 Blower Door Testing

Return to Section 2.2 Energy Audit Requirements

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

Because the blower door is such an important weatherization tool, it is very important that it be set up and used properly at each weatherization job. The depressurization blower door test is preferred for the New Mexico Energy$mart Program because it takes less time to perform than a pressurization test and 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 (TEC) and Retrotec. Please refer to the manufacturer's instructions for more detailed information.

Refer to Section 3.14 for examples when a blower door test might not be required.

11.1.1 Preparation for Blower Door Test

A. 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.

B. Deactivate all vented combustion appliances before depressurizing the structure. Turn the thermostat down or shut the heating appliance off. A gas water heater may be set on "Pilot" rather than setting the control to "Off."

C. 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.

D. 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.

E. 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.

F. Open all livable areas to the interior of the structure, even if the occupants close them off during the winter.

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

H. Set up the blower door unit in an exterior door opening in an area free from obstructions and wind interference.

11.1.2 Blower Door Test, Depressurization (typical)

A. 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.

B. Install the frame and fabric shroud securely into the doorframe, making sure there are no gaps between any of the components and the doorframe.

C. Set the fan into the panel/frame assembly, making sure that the fabric shroud 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.
D. Set up the digital manometer in a vertical position.
E. 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.
F. Attach the hoses properly to the digital gauge and blower door.
G. Perform a one-point test by depressurizing to -50 Pa (negative fifty Pascals) house pressure or, if unable to reach -50 Pascals, the highest possible house pressure. 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.
H. Determine the CFM_{50} value with the digital manometer.

11.1.3 Blower Door Test, Pressurization

A. Use the pressurization blower door test only if a solid-fuel heating unit or a drip-pot, oil-burning space heater is in operation or, for some other reason, it is approved by the New Mexico MFA.
    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 outdoor side of the fan.
B. Install the door frame and fabric shroud as it is normally.
C. 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 or through established holes in the shroud. The fan speed control must remain on the indoor side.
D. Level and stabilize the fan as necessary.
E. Do not change the fan directional switch from its normal (forward) position.
F. Attach the hoses properly to the digital gauge and blower door.
G. Perform a one-point test by pressurizing to 50 Pa (positive 50 Pascals) house pressure or, if unable to reach 50 Pascals, the highest possible house pressure. 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.

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

11.2 Air Sealing Target (AST)

The crew or subcontractor performing the air sealing work should tighten to the dwelling Air Sealing Target (AST) CFM_{50}. If after sealing up the items listed on the assessor developed scope of work, the crew has the option to continue air sealing under the following conditions:

- There are obvious large leaks that still need to be remedied,
- There are accessible areas of leakage in zones where insulation is being installed such as the attic or crawl space,
- If the final CFM_{50} is lower than 10% of the original, the crew communicates with the energy auditor to re-run the audit with lower numbers.

- If the final cost to air seal is greater than 10% of estimated the crew communicates with the energy auditor to re-run the audit with the higher costs.

The AST is partly determined by dividing volume within the thermal/pressure envelope by 10. For example, if the volume of the thermal/pressure envelope is 12,000 ft^3, the AST is 1200 CFM_{50}. The crew or subcontractor performing the air sealing work should tighten to the dwelling Air Sealing Target (AST) CFM_{50} or lower. This number is only used as a guideline and starting point. The assessor must then apply their knowledge of the house, calculate equivalent leakage area, location, and size of any large holes found during blower door testing, and consider accessibility of the leakage areas to adjust the guideline number. This should reflect what is realistically possible for each individual home.

The CFM_{50} used for this procedure shall correspond with the standard method of determining the blower door test volume. That is, if a basement or crawlspace is defined as being within the thermal/pressure envelope, for the pre- and post-weatherization blower door tests, as well as

those done during air sealing; the basement or crawlspace should be open to the main part of the dwelling.[15]

11.3 Air Handler Pressure Balance Testing

Return to Section 7.2.3 Air Handler Pressure Balance Testing

11.3.1 Introduction

This test procedure is 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:

A. Duct leakage to the outdoors, either through supply or return ducts.
B. 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.
C. Imbalances of air distribution resulting from airflow difference between the supply side and return side of the ductwork. Such an imbalance could result from an restricted return trunk, for example.

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

11.3.2 Whole House Test Procedure

A. Set up the house in winter operating mode.
B. Using a digital manometer, run a pressure hose from the main body of the house to the outdoors.
C. Record any pressure difference between the main body of the dwelling and the outdoors. This is the reference baseline pressure.

[15] For example, if the above-grade house volume is 12,000ft^3, which includes a basement with an average height of two feet above grade, the AST is 1200 CFM_{50}. This volume measurement should not include the part of the basement that is below grade. When performing blower door testing in an attempt to air seal to this 1200 CFM_{50}AST, the basement door should be open. This open basement door includes the above- and below-grade volume of the basement. On the other hand, if the basement is not considered a part of the thermal/pressure envelope, none of its volume would be included in the determination of the AST and the basement door would be closed during any blower door testing.

a. A reference baseline pressure generally is due to stack-effect air leakage (especially if it is cold outdoors) or wind.

D. 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 changes with the air handler on in comparison to 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 the 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).

E. Close all interior doors.

F. 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. It also can increase the air leakage to and from the outdoors when the air handler is running.

11.3.3 Room-to-Room Test Procedure

Return to Section 2.2 Energy Audit Requirements or Section 4.3 Room-to-Room Duct-Induced Pressures

A. With a digital manometer, measure the pressure difference across all interior doors. Record measurements of 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 3 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 3 Pascals and measure the area of the opening in square inches. This is the amount of area:

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, off-set grille or jump duct that must be installed to relieve the pressure imbalance caused by the distribution system when the door is closed.

B. Turn off the air handler and return the house to the condition it was in before testing began.

11.4 Furnace Temperature Rise Measurement

Return to Section 2.2 Energy Audit Requirements, 7.2.4 Measurement of Furnace Heat Rise or 7.2.7 Mobile Home Sealed Combustion Furnaces

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 in ductwork or an under-vented furnace close door; or an over-fired burner. Low heat rise can result from excessive fan speed, excessive duct leakage or leakage at the furnace/plenum joint or an under-fired burner.

To calculate furnace temperature rise, measure the temperature of the air in the supply and return side of the furnace, using the locations listed below for common types of furnaces. Subtract the return air temperature from the supply air temperature. The difference, sometimes called Delta-T, is the temperature rise.

The temperature rise should be within the range specified on the manufacturer's label, or between 40° and 80°F. If the temperature rise is out of range, repair the cause of the problem by removing any restriction to airflow and repairing leaks. Then check the temperature rise again. Patch all test holes with an appropriate material.

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

A. *Up-flow furnaces* (these commonly are 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 to prevent radiant thermal energy from the heat exchanger affecting the reading. 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.

B. *Horizonal-flow furnaces* (these commonly are found in crawlspaces or attics):

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 to prevent radiant thermal energy from the heat exchanger affecting the reading. If access is available, it is preferred to drill a test hole in each of the four corners of the supply plenum, check the supply-air temperature in each and average these readings for use as the supply temperature.

b. *Return side*: Drill a hole and insert the thermometer into the return plenum approximately 2 feet before the filter.

C. *Down-flow furnaces* (these commonly are found in mobile homes):

a. 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.

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

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

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

d. *Supply side:* 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.

e. *Return side:* Place the thermometer probe at or through the slots in the blower compartment cover near the top of the furnace.

D. No matter the furnace type, patch all test holes with an appropriate material.

11.5 External Static Pressure Testing

Return to Section 2.2 Energy Audit Requirements or Section 7.2.5 Measurement of Ductwork External Static Pressure

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 manufacturer maximum ESP for a residential air handler is 0.5 inches of water column (IWC) or 125 Pascals for systems with a coil and filter. Systems without a coil and filter would be expected to have a lower ESP if running perfectly. However, most tested ESPs are going to be higher than 125 Pascals because few systems run perfectly.

A. Find the manufacturer's recommended ESP value on the name plate of the unit. 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.
B. Make sure the furnace filter is in place. A clean filter is preferred.
C. 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 3-5 duct diameters downstream of the air handler blower.
    b. Don't measure air conditioning coil until it shipped with the 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) the air conditioning coil. Take care that the coil is not damaged by your actions.

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

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

   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 state 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.

E. Patch all test holes with an appropriate material.

11.6 Duct Leakage Testing

Return to Section 4.5 Duct Leakage, Section 7.5.2 Central Space Cooling Equipment, Section 7.5.4 Heat Pumps, Section 7.6.1 Ductwork Inspection, Cleaning and Sealing or Section 8.9 Ductwork (Mobile Homes)

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 envelope 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 envelope. Mobile home ducts and site-built homes with ductwork in crawlspaces or attics are susceptible to leakage to and from the outdoors.

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

11.6.1 Subtraction Method for Site-Built Dwellings with Ductwork Outside of Thermal/Pressure Envelope

Entry for NEAT needs sufficient data to evaluate duct leakage. The subtraction method, when performed correctly, will provide this data.

A. Conduct the routine whole house depressurization test.
   a. All normal procedures for blower door test should be followed such as turning the air handler off, removing air filters, closing exterior doors/windows, sealing combustion air intakes, and depressurizing the building by 50 PA, and recording the CFM50 reading.

B. Obtain a CFM 50 number with the building envelope only. The only difference with this test is the registers are taped and this number is typically less than the previously obtained CFM50 number.
   a. Tape off all registers, supply, and return. Tape used should be a temporary register sealing tape or high-quality painter's tape.
      i. Be careful not to apply it in such a way that when removed, the interior paint of the wall is removed with it.
   b. Once all the registers are taped securely, obtain your CFM 50 number. If this number is not less than the original number, check your configurations, set up, and tape application before trying again.

C. With the tape still on the registers, measure the pressure in the duct system with the blower door still running at 50 Pa WRT outside.
   a. This is the pressure in the duct system WRT to the building.
   b. Find the Subtraction Correction Factor (SCF) by using the chart provided on this link: energyconservatory.com/wp-content/uploads/2017/08/Blower-Door-Subtraction-Method.pdf

c. Multiply the difference between the initial blower door reading and the envelope only reading by the SCF. This is the number that is entered into NEAT.

NEAT Entry for Subtraction Method

Duct Operating Pressures Before Duct Sealing

- Before taping the registers, measure the operating pressure of the return and supply plenums with a pressure probe through holes drilled near the air handler. The supply

plenum hole can be the same as used for static pressure. The air handler should be on and record the numbers in units of Pa. These will be the before duct sealing numbers.

Before Weatherization with Registers and Grills Open

C. This is your blower door reading before any work is done and corresponding pressure and prior to taping the registers. The default for House Pressure Difference is 50 Pa.

Before Weatherization with Registers and Grills Closed/Sealed

B. This is your blower door reading before any work is done and corresponding pressure (default 50 Pa.), after taping the registers.

Duct Operating Pressures After Duct Sealing

F. This number should be 5 Pa higher than the number that was just obtained with the previous step. For example, if on the previous step, the number was 25 Pa, then what should be entered is 30 Pa..

Duct to House Pressure Difference Before Weatherization

E. This is measured by inserting the probe through the temporary tape of a supply or return register. The default for this number is 50 Pa.

After Duct Sealing and Before Weatherization with Registers and Grills Open

H. This is the estimate of what the blower door reading should be after duct sealing. This is based off the blower door reading with the registers taped and gives the assessor a base number while evaluating the condition of the ducts. Taping of the registers will usually show a number lower than what is possible through sealing accessible locations of boots, elbows, connections, and plenum. This means the assessor must consider how much of the ducts can reasonably be sealed and accessed. The assessor must inspect the entire duct system to decide how much to add to this number that accurately reflects the condition of the system. This number should be the same if duct sealing were to take place before any other air sealing, and the blower door test were to be run.

I. The default for House Pressure Difference is 50 Pa.

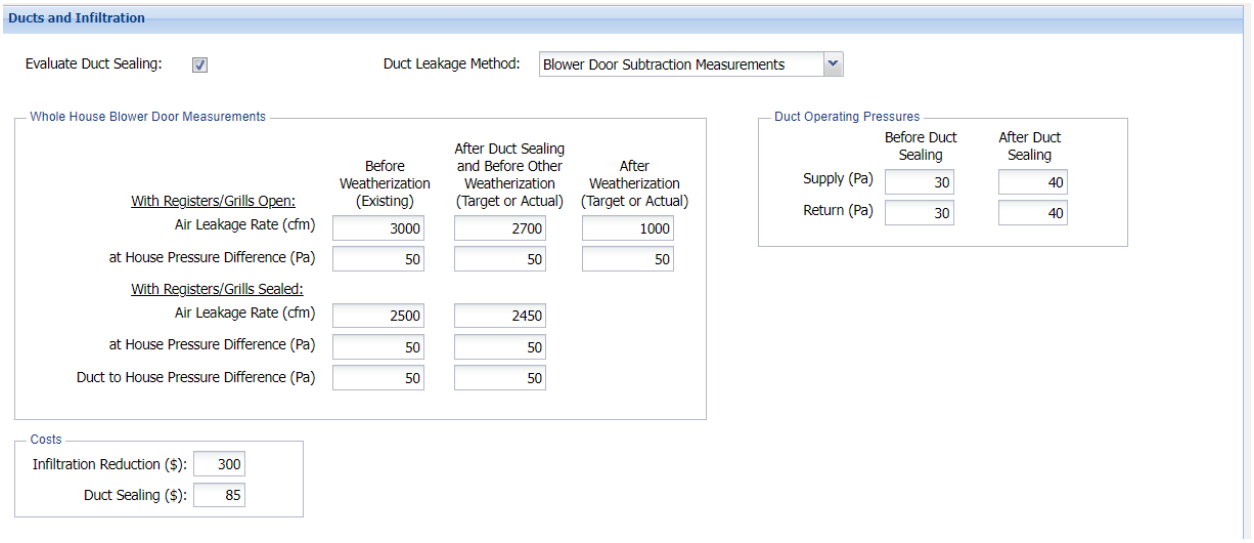
After Duct Sealing and Before Weatherization with Registers and Grills Closed/Sealed

I. This is your blower door reading after duct sealing and before other weatherization with the corresponding pressure (default 50 Pa.), after taping the registers. This number should be lower than the After Duct Sealing and Before Weatherization with Registers and Grills Open from the step above, because there is the added difference of closing/taping the registers. This is not a required test. Final inspectors are encouraged to tape the registers upon final inspections of common housing types or floor plans to obtain this number for future entry considerations of those common housing types. If there is no post weatherization data obtained from the final inspectors, this number should be 50 CFMs lower than the number entered in the above step because it is assumed this number will be lower after both actual duct sealing and taping. The graphic below is to be used as a guide for these entries and only an example.

Duct to House Pressure Difference After Weatherization

C. This can be measured by inserting the probe through the temporary tape of a supply or return register after weatherization, however the measurement is not required because the model must be run prior work. It is typical to enter this number as 50 Pa into the model. After Weatherization (Target or Actual)

B. This is the AST that has been determined using the methodology described in the above section. The house pressure is entered at 50 Pa.



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address on site by an Indoor Air Quality appraisal and by performing the worst-case depressurization testing.

11.6.2 Pressure Pan Testing in Mobile Homes and Site-Built Dwellings with Ductwork Outside of Thermal/Pressure Envelope

Return to Section 7.6.6 Duct Leakage in Site-Built Homes

A. Install the blower door for a depressurization test. Make sure the dwelling is set up for winter conditions.
B. Open all interior doors.
C. Make sure the furnace burner and air handler are off and will not start during the testing.
D. Remove the filter(s) from the duct system for pressure pan test.
E. Temporarily seal outside combustion air inlets or ventilation system connections that are connected directly to the duct system. These connections will show up as large leaks if not sealed prior to testing.
F. Open spaces outside of the thermal/pressure envelope 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, recheck to be sure all operable vents and other openings are open fully.
    a. Open skirting under the mobile home to the outdoor air.
    b. Open a site-built home crawlspace or basement to the outdoors.
    c. In attic spaces containing ductwork, open the attic as much as possible to the outdoors for the test.
G. 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.
H. Depressurize the dwelling to -50 Pascals with the blower door.
I. Make sure the pressure pan is connected properly to the manometer. The proper connection should be reading the space under the pressure pan with reference to the main dwelling pressure.
J. 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 grill 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 connected closely to the same duct run (e.g., 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.

K. 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.
L. 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.
M. Record the pre- and post-weatherization readings in the client file.

11.7 Combustion Safety Testing

Return to Section 2.2.1 Final Inspection Procedures, Section 3.10 Combustion Safety Testing or Section 9.1.1 Water Heater Inspection

11.7.1 Introduction

The purpose of combustion safety testing is to ensure the health and safety of the occupants. All gas and liquid-fueled combustion appliances, regardless of venting type, must receive combustion safety testing, including:

A. Measuring ambient carbon monoxide concentrations throughout the dwelling, but especially in the vicinity of combustion appliances.
B. Gas leak testing and fuel oil leak inspection;

C. Inspection and CO emissions testing of all gas fueled combustion appliances including gas ovens;
D. Worst-case combustion appliance zone (CAZ) depressurization;
    a. Under worst-case depressurization conditions, test vented Category I combustion appliances for:
        i. Spillage; and
        ii. Carbon monoxide emissions within the vent system. These measurements shall always be taken in combustion gases before dilution air enters the vent system. See Table 11-1 for limits.

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

11.7.2 Measure Ambient Carbon Monoxide (CO)

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

11.7.3 Gas Leak Testing

Return to Section 2.2 Energy Audit Requirements, Section 7.2.2 Forced Air Systems or Section 7.3.4 Gas and Oil Leaks

Combustible gas leak testing shall be done on all accessible natural gas and propane piping, including where pipes connect to appliances. **Refer to https://www.bpi.org/sites/default/files/ANSI%20BPI-1200-S-2017%20Standard%20Practice%20for%20Basic%20Analysis%20of%20Buildings%202023-05-19.pdf**

11.7.4 Fuel Oil Leak Inspection

A. 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 exits the oil storage tank, at any line connections and around the oil filter.

Any fuel oil leaks should be repaired by the responsible party using a licensed HVAC professional. If the leak is on the house side of the meter or the side where the oil supply enters the meter, it is the homeowner/subgrantee's responsibility. If the leak is between the meter and the street, it is a job for the oil company. All oil leaks should be documented in the client file. Refer to Section 11.7.3 for gas leak testing procedures.

B. Refer to NM SWS 2.0105.1c Raw Fuel and 2.0111.2a Fuel Leaks for additional guidance.

11.7.5 Inspection, Testing and Adjustment of Gas-Fired Ranges

Return to Section 1.2.2 Non-Emergency One-Day Follow-Up Recommended, Section 2.2 Energy Audit Requirements, Section 2.3 Client Education Recommendations, Section 7.3.6 Carbon Monoxide Emissions, Ambient and Flue Gas or Section 9.2 Gas-Fired Cooking Ranges

A. Check for carbon monoxide (CO) in ambient air upon arrival. If greater than 9 ppm, determine the source and correct the problem before proceeding.
B. Inspect the gas range installation for code compliance. Refer to the latest edition of the National Fuel Gas Code (NFPA 54), Household Cooking Appliances.
C. Check for gas leaks. If leaks are found, repair and document them before proceeding.
D. 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 connect must connect outside the cabinet and must pass through the wall of the range cabinet.
E. Inspect and test range top burners**.**
F. 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 start-up. They then fall to a momentary plateau before the burner shuts down as part of the duty cycle. The reading of CO ppm must be taken during this stable plateau. Record this "plateau" reading in the client file.

e. If the reading at steady state exceeds 200 ppm as measured, then:
    i. Clean any rust and soot buildup on the spreader plate cause by flame impingement.
    ii. Clean the burner if needed.
    iii. Check for obstructed secondary air. If it is obstructed, remove the obstruction and educate the client 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 sizes 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 pilot orifices.

G. With a manometer (water column gauge), check that the gas pressure is correct. If the pressure regulator requires replacement, do so.

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

Return to Section 1.2.2 Non-Emergency One-Day Follow-Up Recommended, Section 1.2.3 Non-Emergency Five-Day Follow-Up Recommended, Section 7.2.7 Mobile Home Sealed Combustion Furnaces, Section 7.3.5 Venting System Spillage or Section 7.3.7 Combustion Safety Testing

The purpose of worst-case depressurization testing is to ensure the proper venting of all vented-combustion appliances in a dwelling. This testing must always be done before and after all other weatherization work has been completed, given that air sealing directly affects air flow throughout a home. It is required that testing be completed at the end of every work day before the workers leave the site if work has been performed which could affect the draft. 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 in the client file.

The worst-case depressurization test measures the pressure difference between the outside and inside of the house at the combustion appliances in the CAZ. This measurement will

confirm whether there is adequate draft for the vent system of all conventionally-vented combustion appliances. If a house contains more than one CAZ, a worst-case depressurization test must be performed for each area.

11.7.6.1 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:

A. If the house or mobile home is all-electric with no combustion appliance, woodstoves, fireplaces, appliances that are all sealed-combustion (direct vent), or unvented (vent-free), a worst-case depressurization test does not have to be performed. Worst-case testing is not required for solid-fuel appliances as long as the appliance is code-compliant.

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

11.7.6.2 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).

A. Consideration must be given to:
    a. The types and locations of heating systems.
    b. The location and CFM rating of all exhaust 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.

11.7.6.3 Procedure Set-up

A. 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, lengthen time average setting on the digital manometer to reduce pressure reading fluctuations.

B. Record the outdoor temperature on the Combustion Safety Testing form for this test. Other information should also be recorded on this form during the test procedure.
C. Deactivate all combustion appliances by turning them off or setting the control to "pilot."
D. Close all operable vents (e.g., a fireplace damper).
E. If there is a furnace, replace or clean the filter if it is dirty.
F. Check and clean the lint filter in the dryer.
G. Set up pressure houses so that the pressure differential of the CAZ with reference to the outdoors can be measured easily 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 closing off airflow through the hose.
H. 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 Combustion Safety Testing 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.

11.7.6.4 Determining Worst-Case Conditions

A. 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 H above.

Note: If there is a whole-house exhaust fan, it is important to inform the client that operating this fan with the house close up could be very hazardous.

B. If the house contains a furnace/central air conditioner, activate the blower to determine if/how much the furnace contributes to depressurization and/or 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.

C. 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 11.3 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.

D. Close the door to the CAZ. If closing this door results in greater depressurization in the CAZ with reference to the outdoors (e.g., closing the door changes the pressure from -2.0 to -4.0 Pa), leave this door closed. If closing this door decreases the depressurization (e.g., closing the door changes the pressure from -4.0 to -3.2 Pa), leave this door open.

E. Record the net worst-case depressurization; that is, the negative pressure of greatest magnitude in the CAZ with reference to the outdoors after subtracting the baseline CAZ pressure.

11.7.6.5 Verifying Proper Appliance Venting and Carbon Monoxide

A. Note: This test is to be completed under worst-case depressurization. The analyst shall monitor ambient carbon monoxide (CO) concentrations continuously. If concentrations rise to a level of 35 ppm, the testing shall be stopped and the area purged with fresh outdoor air. Before testing continues, the source of this CO must be mitigated.

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

C. After the appliance reaches steady-state, measure the CO in the vent connector of the appliance, ensuring that there is no room dilution air at the point of measurement. See Table 11-1 for CO Limits.

    a. If the CO levels are higher, the appliance must be cleaned and tuned and then retested for CO.

D. Fire all remaining appliances, one at a time, in order of input rating (smaller to larger), testing each one for spillage. All appliances must achieve acceptable spillage 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 (i.e., as you fire up the next appliance, allow the previous one to continue to operate).

E. If spillage 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 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 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 cause by a restriction, the spillage 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 as appropriate);
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 as appropriate).
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.

F. If the dwelling has other combustion appliance zones, repeat the sequence of activating exhaust equipment, door closure, furnace blower activation, recording pressure readings, etc.
G. 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.
H. Seal any holes that were drilled in the vent connector with appropriate materials.

Table 11-1 CO Thresholds for Fossil-Fuel Fired Combustion Appliances

Return to Section 3.10 Combustion Safety Testing, Section 7.3.6 Carbon Monoxide Emissions, Ambient and Flue Gas or Section 9.1.1 Water Heater Inspection

CO Thresholds for Fossil-Fuel Fired Combustion Appliances	
Appliance	**Threshold Limit**

Central Furnace (all categories)	200 ppm air free[16]
Boiler, Floor Furnace, or Gravity Furnace	200 ppm air free
Wall Furnace (BIV)	100 ppm air free
Wall Furnace (Direct Vent)	200 ppm air free
Vented or Unvented Room Heater	100 ppm air free
Water Heater	100 ppm air free
Oven/Broiler	200 ppm as measured
Clothes Dryer	200 ppm air free
Refrigerator	12 ppm as measured
Gas Log (gas fireplace)	12 ppm as measured in vent
Gas Log (installed in wood-burning fireplace)	200 ppm air free in firebox

11.8 Zone Pressure Diagnostics (ZPD)

Return to Section 4.4 Zone Pressure Diagnostics

11.8.1 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 also can be used to measure the size of the leakage paths to various house zones. Leaking air often take a path through to pressure boundaries that have a cavity, or zone, between them. These zones can include attics, basements, garages, knee-wall areas or attached porch roofs.

ZPD testing is recommended by the Energy$mart 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

[16] Air free emission levels are based on a mathematical equation (involving carbon monoxide and oxygen or carbon dioxide readings) to convert an actual diluted flue gas carbon monoxide test sample to an undiluted air free flue gas carbon monoxide level utilized in the appliance certification standards. For natural gas or LP gas, using as-measured CO ppm and O_2 percentage: $CO_{AFppm} = (20.9/20.9\text{-}O_2) \times CO_{ppm}$, where CO_{AFppm} = Carbon monoxide, air-free ppm; CO_{ppm} = As-measured combustion gas carbon monoxide ppm; and O_2 = Percentage of oxygen in combustion gas, as a percentage

dwellings with moderate air leakage, rather than on dwellings with very high or very low air leakage.

ZPD procedures require the measurement of *pressure* differences across air barriers, like the pressure difference between the house and the zone (e.g., the attic), while the house is depressurized or pressurized by a blower door. The procedure also requires 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.

11.8.2 Use of Zone Pressure Diagnostics

These procedures can be used with primary and secondary zones. Primary zones are zones to which there is 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:

A. 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 crawlspace walls.
B. 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 crawlspace into the dwelling.
C. Attics with potential or actual moisture-related problems. This might be the case if:
    a. The attic has obvious moisture problems,
    b. The dwelling has evidence of high relative humidity in winter, or
    c. Ice dams are a concern.

Secondary zones are zones to which there is 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 the 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.