2006 - 2007

Colorado Energy $aving Partners Field Standards Funded by the United States Department of Energy and Xcel Energy

This field guide is the product of a collaborative effort, involving meetings in 2004, 2005 & 2006. The following individuals participated and contributed to writing this document.

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Foreword

The purpose of this document is to provide a clear and brief summary of the requirements and procedures of the Colorado Energy $aving Partners weatherization program. The Energy $aving Partners include the Colorado Governor's Office of Energy Management and Conservation, our 8 local weatherization agencies, and our funders: the U.S. Department of Energy and Xcel Energy.

These standards were developed in a collaberative effort between the E$P State and Local Agency Staff. The policy and procedural requirements in these work standards were enhanced, simplified, and clarified for publication here to make them more useful.

Many individuals contributed to our E$P Field Standards, which have evolved over the past 25 years of weatherization experience in Colorado. The E$P program continues to monitor its energy-saving effectiveness and improve its methodology. As the E$P program improves, this document will evolve to reflect the improvements.

Our mission is to provided quality services that reduce the energy costs of our clients. We also help to improve comfort, health, safety, and home durability by providing these services. We hope that these standards will provide a new initiative for continuous improvement in achieving this mission.

Continuous improvement will result from continuous review. Please feel free to comment and criticize.

—Russ Shaber, Energy Services Supervisor

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CHAPTER 1 2006 E$P FIELD POLICY

The Colorado Field Standards contain policies and procedures necessary to correctly weatherize homes qualifying for the Colorado E$P Program. The purpose of policy is to serve as an agreement between the Governor's Office of Energy Management and Conservation, administrator of the Colorado Energy $aving Partners Program, and its subgrantees—Colorado's local weatherization agencies. This policy contains guidelines and rules for the E$P low-income weatherization program. The procedures that follow this policy are instructions about how to perform energy-conservation measures and necessary repairs.

1.1 DEFINITIONS

Agency: A subgrantee of the Colorado Energy $avings Partners Program (E$P). Currently there are 8 low-income weatherization agencies.

Appendix A of 10CFR440: An appendix to DOE grant guidance that lists acceptable materials for use in DOE-sponsored weatherization.

Beyond the scope: Services not defined by these policies and procedures are said to be beyond the scope of the E$P Program.

Building weatherization report (BWR):

Client file: A file kept at the agency documenting the essential information required by the E$P Field Standards.

Completion: A home, weatherized under E$P policies and procedures. E$P's primary unit of production.

Concern: State E$P staff notifies agency staff of a problem and advises them how to correct or avoid the problem.

Cost-effective: A measure is cost-effective if its savings-to-investment ratio is greater than 1.7.

Disallowed cost: An agency expense that is denied by E$P state staff because of a finding.

DOE: The Department of Energy provides funding and the regulations governing the Weatherization Assistance Program.

E$P: Energy Savings Partners is a low-income weatherization program funded by the Department of Energy and utility companies in Colorado.

E$P Energy Services Supervisor: Russ Shaber

E$P Field Standards: This document containing approved policies and procedures as well as other State guidance.

E$P Program Director: Jeff Ackermann

E$P State staff: The E$P Administrative Program Specialists (Amy Abalos and Nikki Kuhn) or the E$P Energy Services Specialists (Chris Fuller and Andy Cordova)

Field audit: An inspection and record of a home's existing condition in order to plan energy-conservation and repair work.

Findings: Violations of E$P policies or procedures, discovered by E$P State staff. A major finding may be a serious or repeated violation, while a minor finding is less serious and not repeated.

Generic priority list: A list of measures arranged in order of priority in descending cost-effectiveness based on a State-approved computer energy audit.

Go-back: An agency returns to a completion to perform additional work or make corrections in response to a finding.

Grant: The contract and payment agreement between OEMC and each agency.

High risk: A classification given to an agency to warn that disciplinary action or contract termination may be forthcoming.

Inspection visit report: State E$P staff writes a report on quality assurance visit to an agency.

Measure: Weatherization methods and materials used to treat a particular building component.

OEMC: The Governor's Office of Energy Management and Conservation.

Pilot project: A completion that demonstrates a new, different, or innovative procedure not covered by existing procedures.

Policy: General guidance, requirements, and rules of the E$P Program.

Procedures: Approved methods of installing energy conservation measures and repairs.

Quality-assurance visit: E$P State staff visit a local agency to inspect the quality of agency completions.

Re-inspect: To send an inspector from the agency who was not involved with a completion to inspect the completion a second time after initial inspection by an employee involved with that completion.

Respirator: A breathing filter approved by the National Institute of Occupational Health and Safety (NIOSH).

Satellite agency: A subsidiary weatherization operation operating under the direction of an E$P agency on a different premises in a different location.

Savings-to-investment ratio: The ratio of life-cycle savings to life-cycle costs adjusted for inflation, energy-cost escalation, and the time value of money.

State-approved computer energy audit: NEAT, the *National Energy Audit Tool*, is approved for analyzing site built homes. TAP, *The Audit Program Mobile Home Version 3*, is approved for analyzing mobile homes. These audit programs may be used when the generic priority lists are not appropriate.

State Waiver: is an important policy exception and requires written permission from the E$P State staff.

Subcontractor: A legitimate independent business that contracts with an agency to perform weatherization work.

T&TA visit: E$P State staff visit an agency to provide training and technical assistance (T&TA).

Technical Waiver: Permission granted to waive (not perform) some E$P policy or procedure. Agency waivers are granted by the agency to itself based on agreed policy.

Walk away: An agency declines weatherization services to a client for health, safety, or administrative reasons.

Weatherization: Measures performed to save energy, save money, increase comfort, and enhance durability.

Xcel Energy: Colorado's largest utility company and a funding partner in the E$P program.

1.2 General Policy

1. ⌘The Standards shall apply to all local administering agencies and their sub-contractors providing Weatherization services through the Energy $aving Partners (E$P) program and Xcel Energy of Colorado.
2. Compliance with all policies, documented here is mandatory. Policies that are required will be identified by ⌘.
3. These policies and procedures are not intended to abridge safety, health, environmental, or local codes or other ordinances. Such requirements, if more stringent than these, shall apply; if these Standards are more stringent, then they shall apply.
4. ⌘If compliance with local codes results in a measure becoming not cost-effective, contact the state E$P staff for guidance.
5. ⌘The health and safety of the clients, agency staff, agency subcontractors and the integrity of the building

structure must not be compromised by any work completed with E$P funds.

6. The agency E$P program manager/coordinator has overall responsibility for proper implementation of the procedures and for the quality control of all repair and energy conservation work.
7. ⌘All installed weatherization materials must meet the materials standards taken from Appendix A of 10CFR440, must be of good quality, and must be installed in a safe, cost effective manner.
8. Work not meeting quality expectations may be subject to findings, re-inspections, go-backs, and disallowed costs.
9. If an eligible client moves during the course of the E$P weatherization work, the agency should complete the repair and/or conservation work in progress and any other measures necessary to secure the well being of future occupants, the structure, and the installed conservation materials. However, additional conservation or repair work should not be started.
10. ⌘When problems are found that are beyond the scope of E$P, such as asbestos hazards, roof replacements and high-cost repairs (>$150) not associated with measures, the client and homeowner must be notified and referred to alternative resources (HUD or DOA rehabilitation programs, landlords, LEAP-CIP, etc.). This documentation must be contained in the client file. Weatherization must not proceed until problems that would affect either E$P measures or the health and safety of the client, and are beyond the scope of the program, are remedied with non-E$P funds.
11. The procedures documented in the coming chapters provide direction for testing, diagnostics, and the installation of energy conservation measures and

repairs. Procedures must be followed as closely as possible. New procedures may be submitted to the State for inclusion in the E$P Field Standards. In order to be considered, new procedures must be effective, efficient, and result in a quality product.

12. ⌘Temporary dwelling structures, recreational vehicles, and buildings not intended for permanent habitation may not be weatherized with E$P funds.
13. ⌘Work must be performed if there is at least 24" of clearance in the work area, and no other constraints exist. Work should be attempted in areas with less than 24" of clearance. Areas that can't be addressed require documentation of a technical waiver.

E$P Program Goal

The Goal for the Colorado Office of Energy Conservation and Management (OEMC) Energy $aving Partners (E$P) program is:

"To provide low-income households with quality energy efficiency services, in a safe and cost-effective manner."

All questions concerning the content or implementation of the E$P Field Standards, should be directed to the E$P State staff.

Allowable Health and Safety Repairs

Health and safety related repairs within the scope of E$P includes the following:

- Furnace replacement.
- Carbon monoxide mitigation.
- Heat exchanger replacement.
- Burner replacement.
- Installation of combustion-air duct.

- Materials to repair gas/propane leaks.
- Propane sniffer for below grade use.
- Chimney cleaning/lining.
- Water heater tank replacements (not fuel conversions).
- Carbon monoxide and smoke detectors.
- Installation of mechanical ventilation systems
- Ground moisture barrier
- Clothes dryer venting
- Plumbing repairs
- Sump pump repair
- Bulk water drainage materials

See "Health, Safety, and Durability" on page 39.

Allowable Repairs Necessary to Install Measures

Necessary repairs completed with E$P funds include the following:

- Electrical repairs
- Structural repairs (include roofing, siding, ceiling, floor, foundation, and mobile home belly repairs) that are necessary for the installation of energy conservation measures.

See "Necessary Repairs" on page 39.

1.3 Agency Obligations

Unit File Documentation

⌘Each client file must contain:

- An indication of the priority list that was used for the unit.
- All required combustion-appliance documentation.
- Documentation of the initial field audit, including the auditor's name and the date of the initial audit.
- Results of a pre- and post-weatherization blower door test.
- An inspection form signed by an agency staff person.
- Accurate records of all materials installed.
- Documentation of state waivers.
- Documentation agency waivers.
- Documentation of notification to owners and clients of health or safety problems, including a mold inspection form, that required weatherization work to be terminated.
- A Refrigerator Replacement form. The form must contain metering or other cost-effectiveness documentation, and an agreement signed by the owner of the existing refrigerator.

See "File Review and Completion" on page 34.

Client/Owner Education

⌘Client education must be provided.

⌘All clients whose homes were built before 1978 must be given an EPA Lead Awareness pamphlet. A client signature is not

required. Agencies must not exceed the DeMinimus within the scope of the E$P program.

See "Client Education" on page 35.

Repairs and Owner Participation

⌘Repair costs must either meet the cost-effective criteria, be allowed under Health and Safety, or the property owner must pay for the repair. *(See "Walk-Away Policy")*

Agency Final Inspections

- ⌘Agencies must use properly trained and qualified auditors and inspectors.
- ⌘A qualified staff person must perform a final inspection after all work is completed. The final inspector must ensure that all measures required by the E$P Field Standards have been installed, and that the work quality meets expectations.
- ⌘Each completed unit must be inspected and the inspection must be documented in the unit file. No dwelling unit may be reported as completed until all weatherization materials (other than refrigerators) have been installed and the agency has performed a final inspection(s) including any mechanical or subcontractor work performed.
- ⌘All installed weatherization materials must meet the materials standards taken from Appendix A of 10CFR440, must be of good quality, and must be installed in a safe and effective manner.
- Based on findings noted in a State visit, the State E$P office may require an agency to re-inspect up to one hundred percent of installed measures if the quality of completed work is perceived to be deficient. Re-inspec-

tion is performed by someone other than the auditor or crew members, who worked on the home.

See "Final Inspection" on page 33.

1.4 State Visits, Findings, and Discipline

E$P State staff regularly inspects the completions of its agencies. All installed materials must be effective, safe, of good quality and appearance. Discoveries of violations of policies and procedures are called findings. Major findings are serious and/or repeated. Minor findings are minor and/or not repeated.

Work not meeting quality expectations may be subject to findings, required go-backs and/or disallowed costs.

⌘All sub-contractor work must pass an inspection by qualified local agency staff, prior to payment.

⌘Sub-contractor work not meeting quality expectations that requires correction, will be done at the sub-contractor's expense.

State E$P Agency Visits

Agency visits include quality assurance inspections and also training and technical assistance (T&TA). A visit report may include inspection and/or T&TA information.

- E$P State staff, or their representatives, will inspect 5% of planned completed units for quality assurance.
- An inspection visit report will be provided to agencies within thirty (30) days of the visit.
- ⌘Agencies must contact the State E$P office within thirty (30) days to verify actions on required responses to inspection visits.

- ⌘Agency appeals to inspection reports must be made in writing to the Energy Services Supervisor within twenty (30) days from the report date.
- ⌘Required Go-backs must be completed within 60 days of receipt of the report, or 30 days after the decision of the final appeal.
- ⌘Appeals to Energy Services Supervisor decisions must be made in writing to the State Program Manager within ten (10) days of receipt.
- The E$P State staff will select the units to be inspected by reviewing the E$P database and/or by reviewing submitted building weatherization reports (BWRs) and selecting units. Inspection visits may focus on problem areas.
- The E$P quality assurance inspection will determine that all materials reported on the (BWR) are present in the unit and that all energy saving measures listed on an accurate (generic or specific) priority list are installed.
- ⌘The correct use of an approved generic priority list is required. This will be determined by the E$P Energy Services staff through completed field unit and client file inspections.
- Use of The National Energy Audit Tool (NEAT) and The Audit Program (TAP 3) are allowed in individual cases when using the generic priority lists are inappropriate. ⌘Agencies are required to document input for all applicable information on costs for measures, materials and fuel types used in these audits. Additional information detailing the agency method for insuring accuracy of the input data must be submitted as well.
- Installed materials will be inspected by the E$P State staff, or their representatives, for effectiveness, safety, workmanship, overall appearance, and compliance with the E$P Field Standards.

- Compliance with the E$P Field Standards for combustion appliance safety will be determined by the E$P State staff through completed field unit inspections.
- If a measure or repair installed under E$P is determined not to be in compliance with the E$P Field Standards, and a State waiver has not been issued, then the expenditures for that measure may be disallowed.
- Legitimate client complaints, received by the E$P State staff, may result in the agency being required to return to correct the situation, and may result in an increased inspection rate by State staff for that agency.
- Deficiencies, poor workmanship, or improper application of methods, techniques, or materials listed under the procedures sections will be considered a finding.
- Concerns about agency operations, tools, or equipment will be noted and discussed on an inspection report.
- Similar concerns that are found on more than one inspection visit may result in the agency being prohibited from performing the specific procedures until they have met the conditions of an improved quality implementation plan, approved by E$P State staff.

Findings

Any non-compliance with an E$P policies or procedures constitutes a finding. Major findings are severe or repeated. Minor findings are less severe or not repeated. Examples of major findings include the following:

- The health and safety of clients, agency staff, or agency subcontractors, or the integrity of the building structure is threatened by work completed with E$P funds.
- A weatherization-related health or safety problem is created by, exacerbated by, or not corrected by the delivery of E$P services.

- The omission, without appropriate authorization, of a required cost-effective measure, a necessary repair, or a required health and safety repair.
- Poor-quality work, materials, or equipment that results in significantly degraded performance or appearance of measures or repairs.
- Major expenditure of funds on measures that are not included on the appropriate generic priority list, or are not required in the E$P Field Standards.
- Expenditure for materials not listed in Appendix A of 10CFR440.
- Any action or lack of action that may result in a liability that threatens E$P grant funds.

Examples of minor findings include the following:

- A single occurrence of poor-quality of work, materials, or equipment that results in minor degradation of performance or appearance of measures or repairs.
- that results in minor degradation in the performance or the appearance of a measure.
- Work site clean up that does not meet the satisfaction of the client or the State Inspector.
- Required energy conservation measures that are not installed, but would not contribute a large energy savings.
- Required health and safety measures that are not addressed, but are not threatening the health or safety of the client.

T&TA Visits

No findings will be cited during T&TA visits. Recommendations for agency actions may be issued to agencies based on cir-

cumstances observed and guidance will be offered on the visit report provided to the agency.

Appeals Process for State Visit Reports

Agencies may appeal inspection reports to the Energy Services Supervisor. Agencies that don't agree with the decision of the Energy Services Supervisor, may submit appeal to the E$P Program Director. Appeals should be submitted in writing within thirty working days of receipt of the inspection report.

High-Risk Status

- Numerous or repeated major findings may result in a recommendation by the E$P State staff to the Energy Services Supervisor that an agency be placed on high-risk status. The E$P Energy Services Supervisor, if in agreement, will then forward the recommendation for high-risk status to the E$P Program Director for disposition.
- If the E$P Program Director places a agency on high-risk status, it is likely that special conditions will be placed upon the agency's grant until the agency complies with E$P Field Standards.

1.5 Standards Amendments

The E$P Field Standards may be amended and/or revised by the E$P State office to reflect changes in State and Federal regulations, state-of-the-art technology, and the prevailing wisdom of energy conservation in existing buildings.

Amendments and revisions to E$P Field Standards will not become effective until thirty (30) calendar days from the date of agency notification, except for the following conditions:

a. State or Federal law or regulation changes mandate immediate implementation;

b. The proposed amendment and/or revision is necessary to protect the health and welfare of Colorado citizens in the case of an emergency, such as a threat to life, limb, or personal property.

Agencies may submit comments and suggested changes or revisions to these Standards to the E$P State staff. E$P State staff may request supporting documentation.

1.6 E$P Field Standards Waivers

There are two types of waivers intended to permit exceptions to E$P Field Standards.

Agency waivers exempt the agency from performing a required measure:

- If it is technically not possible to install the measures.
- If conditions exist, and cannot be overcome, that would make the installation of the measure unsafe.
- The installation of the measure would threaten the health or safety of either the client or the worker.

State waivers permit policy exceptions:

- State waivers will be granted on a case-by case basis in writing.
- ⌘Work may proceed only after assignment of a State waiver number by the E$P State staff.
- ⌘Fuel conversions, multi-family building type 3 & 4 projects, and pilot projects require State waivers.
- ⌘Agencies who are unable to provide services according to the E$P Field Standards because of Local Codes must supply written documentation to the Energy Services staff and request a State Waiver.

1.7 Technical Requirements

Energy Audits

⌘A field audit of each unit must be conducted and documented in the client file. The field audit must include:

- An assessment of health and safety hazards; assignment of work based on an approved priority list; a blower door test; a duct assessment; an insulation assessment.
- The appropriate State-approved generic priority list must be used to determine which measures are cost-effective to install. The client file must contain documentation of which generic priority list was used.
- A site-specific computer energy audit may be used if unusual circumstances exist and the result of running the audit would help to clarify which measures should be installed. The client file must have an accurate priority list generated by this State-approved computer energy audit.
- Multi-family buildings Type 3 & Type 4 require agencies to consult with the E$P State staff in the development of an appropriate priority list.

See "Audit Procedures" on page 27.

Insulation

Attic insulation

- ⌘A "Certificate of Insulation" must be posted if insulation is installed.
- ⌘Insulation must be installed in such a manner that ensures complete coverage at the thermal boundary and

a consistent R-value, except where physical constraints may exist.

- ⌘Attic repairs must be completed in a manner that protects the added insulation material and coverage.
- ⌘Fiberglass insulation must not be left exposed in living areas.
- ⌘Attempts must be made to insulate attic areas with knob and tube wiring. However, it is not allowable to install insulation in a manner that eliminates free air space around knob and tube wiring.
- ⌘All attic non-rated heat sources shall be blocked with rigid non-combustible material to provide at least 3 inches, but no more than 6 inches of space between the heat source and insulation Rated heat sources may be blocked to their rated distance.

See "Attic Insulation" on page 116.

See "Blowing Mobile Home Roof Cavities" on page 157.

Sidewall insulation

- ⌘Cellulose sidewall insulation must be installed to at least 3.25 pounds per cubic foot density, and in such a manner that does not allow settling of the material to occur. Proper use of a fill tube is necessary to consistently achieve this density.
- ⌘Sidewalls must not have voids totaling more than 5% of the net wall area, excluding those areas that may receive a technical waiver such as areas around heat sources, unsafe electrical wiring, or other similar circumstances.
- ⌘Agencies must obtain a warranty, of at least one-year, against voids of more than 5% (as described above) from subcontractors.

See "Wall Insulation" on page 126.

See "Mobile Home Wall Insulation" on page 167.

Sub-floor Insulation

- ⌘Crawlspace moisture problems must be addressed by source control. This usually involves installing a ground moisture barrier or correcting drainage problems.
- ⌘Foundation walls must be insulated so that no portion above-grade wall is left uninsulated.
- ⌘Sub-floor insulation should provide as continuous a thermal boundary as possible.
- ⌘Sub-floor insulation must be fastened securely in place.

See "Floor and Foundation Insulation" on page 142.

See "Mobile Home Floor Insulation" on page 170.

Air leakage and convection

- ⌘Air leaks and convective bypasses must be assessed and corrected.
- ⌘The cost-effectiveness of the air leakage reduction must be determined and documented in the client file.
- Technicians should not perform intentional air sealing when a building is below 2000CFM @ 50Pa. *See "Building Tightness Limits (BTL)" on page 112.*

See "Air Sealing" on page 103.

See "Mobile-Home Air Sealing" on page 152.

Windows and Doors

- Windows, on an individual basis, may be repaired, replaced, or a storm installed over them, if they are damaged and leaking large amounts of air.

- Individual single pane prime windows may be considered for, but are not required to be replaced. Use an appropriate cost-effective analysis to determine if it is cost-effective.
- ⌘Storm windows must be installed when cost-effective and feasible.
- Individual doors may be repaired or replaced provided it is cost-effective to do so, or they are severely damaged and beyond repair.

See "Mobile Home Windows and Doors" on page 179.

Ducts

- ⌘Ducts must be cleaned to remove objects that impede airflow.
- ⌘Ductwork outside the thermal boundary must be reconnected, sealed, and if uninsulated, they must be insulated to at least an R-11.
- ⌘Large duct leaks to unintentionally heated areas inside the thermal boundary must also be sealed.
- ⌘Return air ducts in the vicinity of combustion appliances, except gravity systems, must be sealed to eliminate the potential for back drafting.

See "Duct Sealing" on page 114.

See "Mobile Home Duct Sealing" on page 153.

Combustion Appliance Safety

- ⌘Each client file must include documentation of all work done to the water heating and space heating combustion appliances.

- ⌘Clients may not be left without heat during the heating season. Agencies must respond to heating emergencies as quickly as possible.

See "E$P Combustion Appliance Procedures" on page 82.

Heating System Replacement

⌘Subcontractors must comply with the same standards as agencies when replacing heating systems.

Heating system replacements are an allowable expense in the E$P Weatherization Program.

⌘Heating systems in client-owned homes must be replaced if the heat exchanger is cracked.

In the case of rental units, heating systems may be replaced under the following conditions:

- Open-combustion mobile home furnaces with safety problems.
- Repair costs in excess of 40% of replacement cost.
- Building owners must contribute at least 50% of replacement costs, unless the owner qualifies for the E$P Program.
- When the furnace has chimney problems, consider a 90+ condensing furnace.

Domestic Hot Water

- ⌘Domestic water pipes likely to freeze must be insulated.
- ⌘Electric water heaters outside the living space, including mobile home water heaters in exterior closets, must be insulated if the total existing tank insulation is less than R-11.

- ⌘Gas water heaters outside the living space of the structure, including mobile home water heaters in exterior closets, must be insulated if the existing tank insulation is less than R-7.
- ⌘Domestic hot water temperature must be measured.
- An auditor or technician may adjust the water temperature down to 125° from a higher temperature with the client's approval.
- Water heaters may be converted from electric to gas fired, if the total cost does not exceed $700.00.
- ⌘Rental properties require a minimum 50% of the total cost of the water heater conversion to be paid for by the property owner.

See "Water-heating Energy Savings" on page 69.

E$P Plus Pilot projects

Potential Pilot Projects:

- Evaporative cooling to replace window mounted air conditioners.
- High efficiency water heaters - but not tankless.
- Renewable energy space or domestic water heating systems.

Pilot Project Proposals

- Agencies must submit a proposal to the state E$P staff for approval prior to starting an E$P Plus pilot project.
- Training on energy use analysis will be provided.
- State staff will assist in researching existing evaluation reports.

- Agencies will work with state staff on cost and energy savings estimates.
- Agencies will include pre and post installation project analysis.

1.8 Health and Safety

- ⌘Weatherization services must be provided in a manner that minimizes risks to workers, clients, and clients' homes.
- ⌘Weatherization services may not begin until health and safety problems, beyond the scope of the E$P program, are removed.

See "Hazard Assessment and Denial of Service" on page 47.

- ⌘Agencies must have in place and enforce a health and safety plan.
- ⌘The agency's health and safety plan must comply with State and federal requirements for worker and client health and safety.

Client Health and Safety

- It is the agency's responsibility to comply with applicable Federal and State laws.
- ⌘Building owners and clients must be notified of any health or safety problems that require weatherization work to be terminated.
- ⌘Repair of moisture problems, which could degrade or diminish the effectiveness of weatherization measures, is required.
- ⌘Combustion appliances must be tested for carbon monoxide, spillage, and gas leaks. Problems found during testing must be corrected in an efficient and timely

manner. *See "E$P Combustion Appliance Procedures" on page 82.*

- ⌘Client files must include documentation of all safety tests and work done on combustion appliances.
- ⌘Agencies and their contractors are required to follow procedures to protect their clients from hazardous materials and dust associated with weatherization work. *See "Dust Control" on page 44.*

Safe Materials Installation

- Product bid solicitations should include language describing the manner in which the product will be used, and should include language that states that products offered in the bid response must be appropriate for that use.
- ⌘Agency field staff must install such products in accordance with the manufacturer's directions.
- Agencies are reminded that they must determine if the client has pre-existing health problems that could be affected by weatherization work or materials, and must take appropriate actions to protect the client's health.
- ⌘Agencies must provide specific instruction to their field crews directing them to take precautions or waive measures, if the client's health could be adversely affected.

Staff Health and Safety

It is the agency's responsibility to initiate and maintain programs comply with Occupational Health and Safety Act Regulations (29 CFR 1910 & 1926), and any other applicable Federal and State laws enacted to protect worker safety.

⌘Weatherization services must be provided in a manner that minimizes risk to workers.

⌘Sub-contractors are required to follow procedures set forth in the E$P Field Standards, and to meet DOE Health and Safety requirements.

See "Worker Health and Safety" on page 55.

Mold Policy

⌘Weatherization work must be performed in a manner that does not contribute to mold problems.

⌘Mold testing, abatement, re mediation, or the removal of mold may not be done with E$P funds.

E$P funds may be used to correct conditions to allow for weatherization measures to be installed, or to protect the health and safety of workers and clients.

⌘Agencies must inspect for mold during the initial energy audit. The results must be documented in the client file by completing the E$P Mold Inspection and Release Form.

⌘Clients and landlords must be notified, in writing, when a mold problem is found.

If there is suspected mold growth in the HVAC system, do not operate the system. Limit HVAC work to checking for visual indicators of carbon monoxide (carbon) and spillage.

Walk Away Policy

The following are guidelines for determining situations that are "beyond the scope" of weatherization. Generally these include situations that would put workers health at risk, may cause undue liability to the agency, or require expenditures that are beyond the cost-effective guidelines.

Hazards

- Excessive moisture that cannot be mitigated within the scope of the program.
- Excessive mold growth that would affect worker or client health.
- Sewer gas, plumbing problems or raw sewage that is of a magnitude that it puts worker health at risk.
- Volatile organic compounds or other chemicals that present a risk to worker or client safety.
- Client behavior that puts workers at risk, or makes working conditions intolerable.

Combustion Appliances

- Combustion systems that are operating in an unsafe manner, and cannot be repaired or replaced without excessive expenditures of program funds.
- Unvented combustion space heating appliances used as the primary heat source and/or are creating an indoor air pollution problem. These appliances should be permanently disabled or destroyed with the permission of the client, before work continues.

Structural Problems

- The building structure or foundation is not sound.
- The home is being renovated and will require more than one sheet of drywall to complete.
- The roof has deteriorated and is in need of replacement, and it is not cost-effective to replace.
- There are major electrical problems that are not cost-effective to repair.

Agency Policy

Each sub-grantee should develop a consistent policy for dealing with "Walk Away" situations. This policy should be applied

equally and fairly to all clients. Clients should not be denied services because of a "Walk Away" situation. Other sources of funding to correct problems should be investigated. The client/landlord should be given the opportunity to correct the problem and notify the agency when corrections have been completed, so that the weatherization work can be completed.

CHAPTER 2 AUDIT AND FINAL INSPECTION

The audit and final inspection are the agency's formal interaction with the clients and their homes. This process includes the following procedures.

- Explaining the weatherization process to the clients.
- Prioritizing energy conservation measures.
- Noting health and safety concerns and planning to mitigate them.
- Educating clients about how to save energy in their homes.
- Inspecting the work, including required energy-conservation measures and health-and-safety improvements.
- Checking the client file to verify that all required forms and documentation are present, complete, and accurate.

2.1 AUDIT PROCEDURES

⌘The field audit must include at least the following activities:

Information collection:⌘: Assess and record the existing conditions of the dwelling and its mechanical systems.

Dwelling evaluation: ⌘Evaluate the existing conditions for energy conservation opportunities and energy related health/safety problems.

Dwelling strategy: ⌘Develop a strategy for improved energy efficiency and for correcting energy-related health and safety problems.

INFORMATION COLLECTION

Look for, check, and document relevant characteristics of the dwelling's exterior and interior.

Dwelling exterior

- Chimney or other vent location/condition.
- General roof condition.
- Window/door/siding condition.
- Foundation condition and amount exposed.
- Site drainage.
- Crawl space/basement entrance.
- Additions to the dwelling.
- Air leakage between the house and the garage.

Dwelling interior

- Moisture, mold, or evidence of past moisture problems.
- Energy related health/safety hazards.
- Inspect the attic for the presence, depth, and type of attic insulation.
- Inspect the condition of any attic and the wiring.
- Major air leakage holes and bypasses.
- Check exterior walls for insulation, cavity depth and batt thickness. Check remodeled areas and additions separately.
- Check the crawlspace, belly, or basement boxsills for insulation.
- Measure the building dimensions. Document wall and attic square footage.
- Check the air leakage rate with the blower door.

Combustion appliances

- ⌘Test all combustion appliances for gas leaks, carbon monoxide and spillage. Visually inspect furnace heat exchangers for cracks.
- ⌘Stop work on rental units with cracked heat exchangers, until the owner has agreed to participate in the replacement cost.

Client interview (pre-weatherization)

- ⌘Interview client about problem identification, dwelling use, and comfort issues.
- ⌘Discuss energy conservation opportunities and health and safety issues with the client.

Dwelling Evaluation

- Begin emergency follow-up immediately, if necessary. Contact a supervisor if appropriate.
- Prioritize health/safety activities such as emergency or urgent health/safety deficiencies prior to beginning any work on the building shell. Non-urgent health/safety activities may be completed after building shell activities.
- Take pictures to document hazards, concerns, questionable situations, etc. Make sure digital images can be linked back to the job.
- ⌘Identify potential measures and their associated repair costs. This includes all building shell, baseload, and combustion appliance measures.
- ⌘Prioritize repair activities. Complete repairs necessary to install measures before installing the measures.

- Compare energy use information to the condition of the home. Energy use is the best predictor of potential savings.
- ⌘Determine from the generic priority list which measures are cost-effective. Get bids for repairs if necessary.
- ⌘Determine if optional measures would be appropriate and cost effective for the home. If they are, discuss them with the client. Take extra time to convince the client to allow measure, such as wall insulation.
- ⌘Calculate the correct number of insulation bags, rolls of insulation, or other materials needed to complete the job.
- Prescriptive measures, such as duct sealing and air leakage assessment may need to be performed on any given house.
- Determine the most efficient work-flow for completing the job. Talk to the client about scheduling crews and their availability.

Dwelling Strategy

- ⌘Use the state provided Generic Priority Lists for your region. Use the list that most closely approximates the fuel and house-type for the situation.
- The Colorado E$P Program is approved to use the NEAT audit for site built housing and TAP for mobile homes. These computer audit tools should only be used in unusual situations, and on a case by case basis.
- Modular homes are typically constructed using a similar design to site-built homes. Use the site-built Generic Priority List for these homes. Report them as "Site". If the sub-floor area more closely resemble a mobile home, treat it as you would a mobile home.

2.2 Doing the Work

Installation of Measures

Weatherization measures serve three purposes:

1. Conserve energy and reduce household energy bills.
2. Protect household members from energy-related hazards.
3. Protect homes from damage caused by fire or moisture.

Though installation activities may vary from house to house, the following work-flow for installers pertains to most homes.

When you receive the weatherization file:

- Review the audit and work order.
- Make sure you can find the home. If you are unsure, get directions.

Before you leave the shop:

- Understand what work has been called for and what materials will be needed.
- Note any mechanical work that was to be completed prior to the start of building shell activities.
- Know what repairs need to be completed before installing weatherization measures.
- Clarify with the auditor anything about the job that is unclear or incomplete.
- Contact the client to make sure that they will be home and that they understand what you will be doing.

At the job site:

- Walk around the exterior.
- Confirm the information on the audit form.

- Document any problems that could interfere with installation activities.

Walk through the interior:

- Confirm the information in the audit.
- Document any problems that could interfere with installation activities.

Contact the auditor or your supervisor if:

- There are problems with heating systems, or if you smell gas. If the gas smell is strong, open windows or evacuate the house.
- Conditions have changed and you can't do your work, or if it will take much longer than normal to get the job done.
- The house is for sale. Do not start any new work.

Talk to the client:

- Explain what will be happening, and approximately how long it will take.
- Ask for the client's assistance for such things as controlling children or pets and moving possessions out of the way.

Complete air leakage tests:

- Set up the blower door and check the building shell for air leaks.
- Check for leakage from the ducts.
- Find and seal large air leaks.
- Check your progress with the blower door after you complete an area.
- Record blower door test results, materials, and your time.
- Stop air leakage work when it is no longer cost-effective.

Complete repairs, weatherization measures, and health/safety activities:

- Repair the building shell where cost-effective and necessary to install measures.
- Install building shell and health and safety materials.

In houses with forced air furnaces:

- Seal supply ducts that are outside of the heated space.
- Seal return ducts that are outside of the heated space or in the vicinity of combustion appliances.

2.3 Final Inspection

Building Shell

- ⌘Review the original energy audit form.
- ⌘Ensure all required procedures were performed.
- ⌘Verify the accuracy of the audit, including measures that may have been omitted.
- ⌘Inspect all work to ensure that standards of workmanship and materials are met. Make sure that the job site is cleaned up.
- ⌘Perform final blower door readings if appropriate.
- ⌘Call for corrective actions where initial work does not meet standards.

Mechanical System

- ⌘Verify that all work was completed as required.
- ⌘Re-test appliances to confirm that they currently operate in a safe/dependable manner.

- ⌘Call for corrective actions where initial work does not meet standards.

Client Interview (post-weatherization)

- ⌘Review all completed work with the client.
- ⌘Ask if the client is satisfied with the work.
- ⌘Ask if the crews were courteous, professional, and cleaned up well.
- ⌘Ask if the client received energy education and filter maintenance instructions.
- ⌘Make corrections only within the scope of program rules and policies.

File Review and Completion

- ⌘Review all required forms for accuracy and completion.
- ⌘Document required go-backs or follow-up work.
- ⌘Get required signatures, if they are missing.
- ⌘Sign and date an inspection form assuring that you have verified that all E$P requirements have been met.

See "Unit File Documentation" on page 8.

Job Completion

- ⌘A job is complete only after all work—crew or contractor—has been completed and has passed inspection.
- ⌘Inspections must be completed by a competent agency employee.

- ⌘Repeated or significant inspection mistakes may be grounds for required reinspection of all of that person's inspected units.
- Provide feedback to crews on work quality: good and bad.

2.4 Client Education

Explaining the weatherization process.

- Introduce yourself to the client and associate yourself with your agency.
- Tell clients that all measures that we install must save at least as much energy as their initial cost, by order of federal regulations.
- Explain to the client that you will need access to all areas of the home including bedrooms, bathrooms, and closets.
- Advise the client that inspection holes may need to be made auditing and inspection purposes.
- Explain the general procedure of the audit and the weatherization process including the blower door test, health and safety tests, insulation levels, etc.
- Keep the client informed throughout the entire weatherization process.

Questions to ask

- Ask the client if there are problems with the furnace, electrical wiring, water heater or any problems in general with the home.
- Are their energy bills high or low?
- Let them tell you about their home. They may have some useful information.

Being respectful

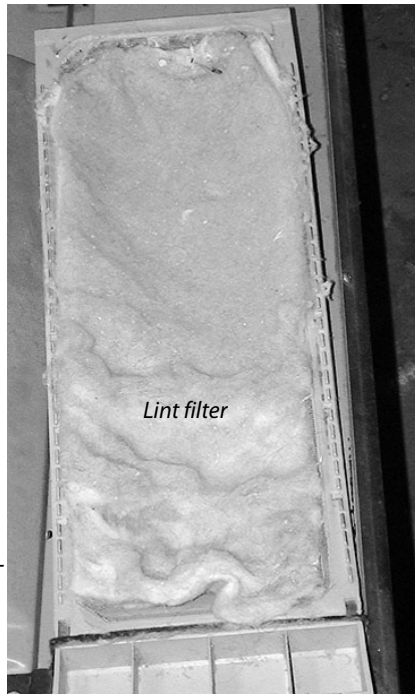
- Listen.
- Be professional.
- Respect their home, their yard, and their possessions.

Suggestions for reducing heating costs

- Provide energy saving tips based on the opportunities that you have learned about while in the clients home.
- Set thermostat back 5 to 15 degrees at night or when they are away for long periods.
- Open curtains to let the sun during winter days. Close them when the sun goes down.
- Wear warm clothing.
- Don't sit near windows on cold days.
- Check furnace filters monthly and change or clean them as necessary.
- Open all registers and don't obstruct them with furniture.
- Clean supply and return grilles periodically.

Suggestions for saving hot-water and laundry energy

- Wash clothes in cold water unless warm or hot water is needed to get dirty clothes clean.
- Wash and dry full loads of clothes.
- Clean the dryer lint filter after each load.
- Use the electronic cycle. Note the dial reading that gets clothes acceptably dry and use that setting consistently.
- Remove lint and outdoor debris from the dryer vent termination.
- Dry clothes on a clothesline during nice weather.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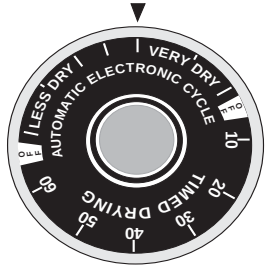
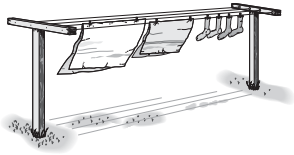
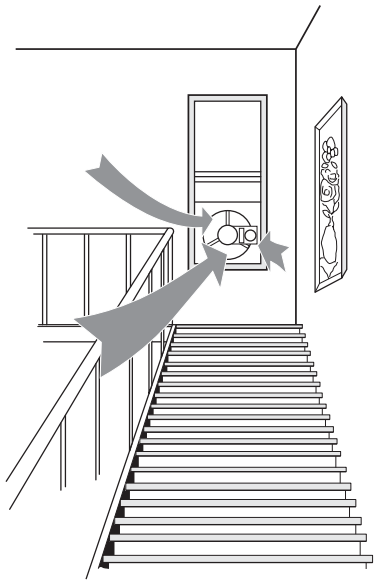




Suggestions for staying cool during hot weather

- Use ventilating fans during the night. In the morning, shut the house up and draw drapes and blinds.
- Place window swamp coolers or circulating fans on the north side, or in shaded window to improve comfort.
- Set your air conditioner at the highest thermostat setting where it still provides adequate comfort.



- Turn off lights and appliances when not in use. They produce considerable heat.
- Close interior doors to limit the area cooled by room air conditioners.

Other energy-saving suggestions

- Turn off lights, TVs, and computers when not in use.
- Cook in a microwave oven to save energy compared to cooking with a conventional range or oven.
- Turn off dishwashers after the cleaning cycle and allow dishes to air dry overnight.

2.5 Health, Safety, and Durability

Health and Safety Repairs

Allowable health and safety related repairs within the scope of E$P include the following:

- Furnace replacements.
- Carbon monoxide mitigation.
- Heat exchanger replacements.
- Burner cleaning.
- Combustion air installation.
- Repairs gas/propane leaks.
- Propane sniffer for below grade use.
- Chimney cleaning/lining.
- Water heater tank replacements.
- Ground moisture barrier
- Plumbing repair materials
- Clothes dryer venting
- Mechanical ventilation system materials

See "Allowable Health and Safety Repairs" on page 6.

Necessary Repairs

Necessary repairs that can be completed with E$P funds include the following:

- Electrical repair materials
- Structural repairs (include roofing, siding, ceiling, floor, foundation, and mobile home belly repairs) that are

necessary for the installation of energy conservation measures.

- Drainage repairs/modifications

See "Allowable Repairs Necessary to Install Measures" on page 7.

Notification

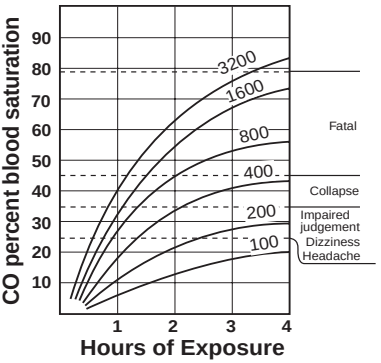
When serious safety problems are discovered that require weatherization work to be terminated:

- Contact your supervisor.
- Inform the client and/or owner about the hazards.
- Write brief file documentation indicating that owners and clients were notified of health or safety problems.

Carbon monoxide danger

Carbon monoxide (CO) is released by combustion appliances, automobiles, and cigarettes as a product of incomplete combustion.

- Low-level CO exposure: (5-to-50ppm in the ambient air) similar to the flu, slowed nerve reaction time, mild drowsiness, nausea, and headaches.
- Higher concentrations (50-to-3000 ppm) severe headaches, vomiting, and even death.



Effects of CO: This graphs curves represent different exposure levels in parts per million.

Sources of carbon monoxide poisoning

- Automobiles idling in attached garages or near the home.
- Unvented gas or kerosene space heaters.
- Backdrafting or spilling of vented furnaces and water heaters.
- Gas ranges, leaky wood stoves, and other combustion appliances located in the living space.

Carbon Monoxide and Smoke Alarms

Installing smoke detectors and CO alarms is not required but is allowed. Use good judgment when considering the installation of these devices.

- All homes should have at least one smoke alarm on each level, including one near the combustion zone and at least one near the bedrooms. Carbon monoxide (CO) alarms are appropriate whenever the CO hazard is considered a likely occurrence.
- Clients should be educated about the purpose and features of the alarms and what to do if an alarm sounds. Follow these specifications when installing CO alarms and smoke alarms.

CO alarms

Homes with unvented space heaters and homes where a furnace return air could backdraft a space heater, wood stove, fireplace should have CO alarms.

- Install according to the manufacturer's instructions.
- Mount at least 5 feet above the floor.
- Mount at least 1 foot below the ceiling.
- Connect to a circuit that is energized at all times.

Don't install CO alarms in these cases.

- In a home that already has a CO alarm.
- In a room that may get too hot or cold for alarm to function properly.
- Within 5 feet of a combustion appliance, vent, or chimney.
- Within 5 feet of a storage area for vapor-producing chemicals.
- Within 12 inches of exterior doors and windows.
- Within a furnace closet or room.
- With an electrical connection to a switched circuit.
- With a connection to a ground-fault interrupter circuit (GFCI)

Smoke alarms

Observe these specifications when installing smoke alarms.

- Install according to manufacturer's instructions
- If mounted on a wall, mount from 4 to 12 inches from the ceiling
- If mounted on a ceiling, mount at least 6 inches from the nearest wall
- Don't install smoke alarms in these cases.
- In a home that already has a smoke alarm
- Within 12 inches of exterior doors and windows

Moisture and Ventilation

- Controlling the source of Indoor Air Quality problems is more effective than adding ventilation. Try to control

the source before considering the installation of mechanical ventilation.

- Ventilation systems are only required in units that are tighter than 15 CFM/person and have a pre-existing moisture or air quality problem that cannot be corrected at the source.
- Provide spot ventilation with exhaust fans in the kitchen or bathroom if moisture is a problem in these areas.
- Kitchen and bath fans must be vented outdoors. Rigid metal ducting should be considered first. Non-vinyl flex duct may be used for runs of less than six feet. Vent duct may be terminated at or in (but not near) roof and gable vents. Vents should not terminate at a soffit vent. Insulate the duct where it is outside of the heated space.
- Manual switches, dehumidistats, and/or timers should be used to control the fan(s).

Adding mechanical ventilation is rare. Most moisture problems are handled some other way. For example: venting the clothes dryer outdoors, educating the client, installing a ground moisture barrier. We occasionally find a situation that really needs mechanical ventilation, usually associated with high occupancy, low-volume housing.

Ventilation can also help in homes with pollutant sources such as smoking, new furniture, new carpet, and various airborne chemicals. Discuss the use ventilation with the client if you detect indoor air pollutants.

See "Correcting Moisture Problems" on page 102.

Sources of moisture

Common sources of moisture are:

- Leaky roofs,
- Damp crawlspaces,

- Poor drainage around the foundation
- Leaky gutters
- Downspouts without extensions,
- Plumbing or sewer leaks,
- Unvented gas appliances,
- Clothes dryers venting indoors,
- Exhaust fans not venting out of the building shell,
- Indoor plants and aquariums,
- Green or wet firewood stored inside,
- Showers,
- Cooking,
- Over occupancy, and
- Hanging wet clothing inside to dry.

Signs of moisture

- Mold and mildew.
- Condensation on windows and walls. (Occasional condensation during very cold weather isn't a major problem.)
- Dry rot and wood decay.
- Water stains and hard cracked soil in the crawlspace.
- Cupping roof shingles.

Dust Control

- All dust is dangerous.
- Clients and workers must be protected from contaminants.

- Respirators should always be worn when working in dusty environments. *See "Respiratory Health" on page 58.*
- The client's living space must be protected from dust generated or disturbed by weatherization work.

Lead-safe weatherization

- Lead base paint safe work practices must be used on homes where painted surfaces will be disturbed that were built before 1978, and have not been tested negative for lead paint.
- Agencies must provide Lead Safe Work Practices training to all employees working in client homes.
- The use of a dust containment system, in conjunction with a NIOSH approved HEPA-filtered vacuum is required when drilling holes through painted surfaces.
- The statutory De Minimus action levels (2 square feet per room on the interior, 20 square feet on the exterior, and 10% of a building component) for disturbing lead base paint should not be exceeded.
- Agencies are prohibited from using E$P funds for performing abatement, stabilization or control of lead-base paint, or to engage in activities that would result in a requirement to abate, stabilize, or control lead-base paint.
- The area under work activities that would disturb painted surfaces should be covered with durable, disposable plastic sheeting.
- NIOSH approved respiratory protection and appropriate personal protective equipment must be worn whenever painted surfaces will be disturbed.
- Agencies must require work related safe hygiene practices. These practices include, at a minimum:

a. No eating, drinking or smoking in work areas;

b. Wash hands and exposed skin before breaks and after working; and

c. Remove respiratory protection, personal protective clothing and equipment before breaks and after working.

Electrical Safety

Check for ground:

- All home electrical systems must be grounded if a new refrigerator will be installed. Acceptable grounding connections include either a grounding rod or to a water pipe that has an uninterrupted electrical connection to the ground.

Check for over amperage protection

- #12 copper or #10 aluminum should be protected by a fuse or breaker rated at no more than 20 amps.
- #14 copper or #12 aluminum wiring should be protected by a fuse or breaker rated for no more than 15 amps.
- Visually inspect the breaker or fuse box to determine wiring and amperage protection size.
- S-type fuses should be installed where appropriate to prevent occupants from installing oversized fuses.

Check for wiring condition

- Outlets and switches must be checked and documented prior to installing insulation in walls or ceiling cavities.
- Wiring splices must be enclosed in metal or plastic electrical boxes, fitted with cover plates before being covered with insulation.

- If it is not possible or if is too expensive to put a splice into a junction box, isolate the splice with fiberglass insulation. Cut a hole in an unfaced R-38 batt. Lay the batt over the splice to leave the splice exposed within the hole. Make sure that blown-in cellulose is kept away from the splice.

Check voltage drop

Wiring in enclosed cavities should be checked for voltage drop if there is any concern over its' condition. Each circuit should be checked at the end furthest from the fuse or breaker box. All electrical outlets in wall cavities receiving insulation must be tested for voltage drop. The voltage drop must be less than 10% if insulation will cover the wiring.

Other Workplace Hazards

Safety always has priority over other factors affecting weatherization operations. Be aware of these most common workplace hazards:

- Driving
- Falls
- Back injuries
- Hazardous materials
- Electrical and tool hazards
- Repetitive stress injuries

See "Worker Health and Safety" on page 55.

Hazard Assessment and Denial of Service

Hazards, improper heating system installation, and problems with the structure must be corrected before work proceeds. Where problems are beyond the scope of the program and can-

not be removed, inform the home owner in writing that service will be denied until the problems are solved. Explain the problems clearly, make recommendations about how they can be solved, and explain that the problems are currently beyond the scope of the E$P program.

Hazard assessment

All situations relating to weatherization work that pose a hazard to the client or the home must be remedied before installing the measure associated with the situation.

Look for and document the following hazards:

- Excessive moisture.
- Friable asbestos that precludes performing a majority of the work.
- Sewer gas, plumbing leaks or raw sewage/feces that puts workers at a health risk.
- Chemicals posing a health risk to workers or clients.
- Client behavior which puts the workers at risk or makes the working conditions intolerable for the workers.

See "Worker Health and Safety" on page 55.

Improper heating system installations

- Combustion heating systems situated in bedroom, bathroom or closet (and not a sealed combustion system).
- Furnaces that have no cold air return and no easy place to put one.
- Furnaces that have no service access.
- Mobile homes with non-mobile home type furnaces.
- Any unvented heater. **Permanently** disable or vent (with client/owner permission) the appliance.

- Any furnace that is installed in a dangerous manner and can not be repaired for under $400.

Structural problems

- The house is structurally damaged or deteriorated beyond repair.
- The foundation will not support one or more of the walls.
- A unit that is under renovation or under construction.
- Over 25% of the roof is in need of replacement.
- Structurally unsound walls.
- Major electrical problems.

2.6 Multi-family Buildings

Multi-Family Building Policy and Protocols

Type 1 - Town House, Row House, Garden Apartments

Characteristics: Heating fuel and electricity are individually metered and paid for directly by client.

Usually have two or three exterior walls. The ceiling and foundation are exposed to the exterior. Each unit has a furnace and water heater.

Procedure: These units are to be considered single family units. Treat as single family units that happen to share some walls. Energy Audit requirements, Generic Priority Lists for site buildings and the E$P Field Standards apply.

Count each unit as one full unit. It is not necessary to assess the entire building shell, just the portions of the building envelop that are exposed to unheated space. Blower door tests are not required. Each unit must have a qualified client occupying the home.

Type 2 - Low and Mid Rise Apartment Buildings

Characteristics: Heating fuel and electricity are individually metered and paid for directly by client.

Each apartment has two or three exterior walls. There are upper and lower apartments. Each qualified unit has either a ceiling or a foundation exposed to the exterior. Each unit has a furnace and water heater.

Procedure: Only units that have at least one surface insulated or receive some other major measure will count as full unit. Each unit may be qualified individually, or two thirds of the entire building occupant capacity must qualify (50% if a 4-plex). It is not necessary to assess the entire building shell, unless all units in the building will be counted. Energy Audit requirements, Generic Priority Lists, and the E$P Field Standards apply. Blower door tests are not required.

Type 3 - Low, Mid, and High Rise Apartment Buildings

Characteristics: There is a central heating system. The building owner is responsible for heating fuel costs. Clients may or may not pay for electricity individually.

Procedure: The E$P Multi-Family Proposal Protocols must be followed. The entire building must be assessed and a proposal must be submitted to the State E$P Energy Services staff for approval. The number of units counted will be based on investment and savings. The number of units to be counted will determined by the state E$P staff. For agencies wishing to submit units for Xcel Energy reimbursement, prior approval will need to be negotiated with the Xcel E$P Program Manager.

Type 4 - Group living homes, Temporary Shelters

Characteristics: These units have sleeping quarters, but no individual kitchen facilities.

Procedure: The entire building shell must be assessed and addressed. If the building floor area is less than 4000 square feet, the agency may count one unit of production for each 800 sq. ft. of floor area. Energy Audit requirements, Generic Priority Lists and the E$P Field Standards apply. If more than four units of production will be counted, Multi-family Proposal Protocols must be followed.

Multi-Family Proposal Protocols

Complete multi-family proposals must be submitted in writing to the state E$P Energy Services staff prior to April 15th of the program year in which they will be completed.

Type 3 & Type 4 buildings, or multi-family buildings of more than five units that are to be qualified under the 50% rule, [10 CFR 440.22(b)(2)] must be submitted to the State E$P Staff for approval prior to initiating work.

The submission or proposal must include the following:

- Client intake and qualification documentation for the appropriate number of clients.
- A thorough assessment of the entire building shell.
- An efficiency assessment of the space and water heating systems.
- An assessment of the electric base load and potential base load measures.
- An assessment of the cooling load and potential cooling load measures.

- A written agreement between the owner and the agency. This agreement must contain:
- A description of the measures that will be installed under E$P, their costs, and their projected completion date.
- Owner contribution information.
- Client benefit information (e.g., how the benefits of weatherization will accrue to the clients).

An Engineers evaluation may be used to determine heating and cooling loads. and to make recommendation for improved energy savings, with prior approval from State Staff.

Use of an engineers evaluation does not negate the requirement for a physical audit performed by the agency, nor does it relieve the agency of any other requirements in the E$P Field Standards, and Policies and Procedures.

Documentation of utility usage.

A prioritized list of measures based on an appropriate computerized energy audit or other approved approach.

The total number of units to be considered.

An estimate of material and on-site labor costs for the project, and an estimate of the agencies material and on-site labor average (average labor hours x average labor rate).

Significant financial participation by the building owner is required for capital intensive measures. This is defined as 50% of the total cost for replacement windows, heating system replacements, and/or refrigerator replacements. A lower amount may be negotiated, based on the financial hardship of the owner and the total energy savings of the project. The minimum participation level shall not be lower than 33% of the total cost for these measures.

In order to qualify a building under the 50% eligibility rule, the agency must also:

Demonstrate that significant energy savings will be achieved as a result of the work.

Obtain leveraged funds for sharing in the cost of projects where there will be major expenditures for measures, other than insulation measures.

Training for maintenance staff should be provided if major work is to be done on the heating or cooling system, and/or there are a significant amount of repairs that are necessary.

Multi-family projects must include plans for tracking post utility consumption for analysis. This information should be used for determining rent rebates, rent reductions, or other benefits that will accrue to the weatherization clients.

Blower Door readings are not required for multi-family buildings. Air leakage work should be performed if a visual assessment of the building shell indicates that there is significant heat loss due to air leakage. Pressure testing individual apartments, if done, must be done using the "balanced fan" technique. Whole building air leakage testing in large buildings, if done, requires the use of large scale equipment.

CHAPTER 3 WORKER HEALTH AND SAFETY

Recognize hazards, communicate with co-workers and supervisors, and take action to reduce or eliminate hazards.

See "Health and Safety" on page 22.

Safety meetings: Safety education and safety meetings are essential parts of a successful safety program.

3.1 FIRST AID

Courtesy FAC Canada

First aid is extremely important but is beyond the scope of this guidebook. All agencies must have training, procedures, and first aid supplies available to their workers, in the field.

- All vehicles should carry first aid kits and eyewash stations.
- Workers should receive training on first aid and cardio pulmonary resuscitation.
- Workers should be instructed on emergency procedures.
- Workers should be trained on the dangers and avoidance of blood borne pathogens (HIV, Hepatitis), toxic

materials, insect and animal bites, hanta virus, and all other workplace hazards.

3.2 New Employees

New hire: New hires are several times more likely to be injured, compared to experienced workers.

New employees are several times more likely to injure themselves on the job compared to experienced workers. New employees should learn proper procedures for the following before attempting them on the job:

- Proper lifting.
- Safe ladder usage.
- Safe operation of the power tools.
- How to use respirators, safety glasses, hearing protection, and gloves.
- How to dress properly for the job—short pants, sandals, and tank tops are not appropriate.

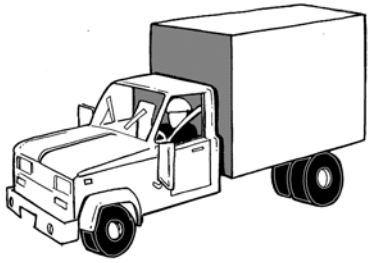
Supervisors must inform new employees about the following:

- Hazardous materials they may encounter on the job.
- How to read the Material Safety Data Sheets (MSDS).
- Alcohol and drugs are banned from the job.
- Cigarette smoke is a hazard to both smokers and to non-smokers, especially in dusty environments.
- Non-smokers must be protected from second-hand smoke.

- The physical demands of the job require employees to be fit.
- New employees must understand that all information concerning their clients must be kept confidential and may not be discussed away from the workplace.

3.3 Driving

Approximately one third of all occupational fatalities in the United States occur in motor-vehicle accidents. To minimize the risk of vehicular accidents:



Safe vehicles: Maintain vehicles in good repair. Drivers and passengers should always wear seat belts.

- Minimize vehicular travel.
- Keep vehicles in good repair.
- Always wear seat belts.
- Properly stow and secure tools and materials when traveling.

3.4 Lifting and Back Injuries

Back injuries account for 20% of workplace injuries. To avoid back injury:

- Get help with heavy or awkward loads.
- Stay in good physical condition.
- Control your weight through diet and exercise.
- Lift with your legs.
- Keep your back straight.
- Adapt equipment for more ergonomic movement.

Awkward loads: Ask for help when moving heavy or awkward loads.

- Minimize awkward movement.
- Set lifting limits.
- Provide training on the causes and prevention of back injuries.

3.5 Respiratory Health

All field workers must be supplied with the proper respiratory protection. Workers are required to wear a respirator whenever they are working in a dusty environment.

Fit testing a negative pressure respirator:

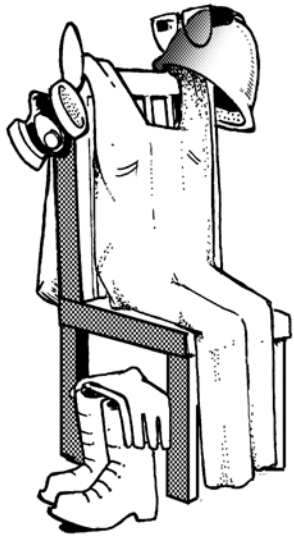
- Put on the respirator.
- Cover and close the exhalation valve with your hand.
- While exhaling gently, there should be no leakage of air around the face.

- Workers with beards, facial scars, and thick temple bars on eyeglasses must take special care to get a good seal when putting on a respirator.

See "Dust Control" on page 44.

3.6 Safety Protection

- Wear disposable coveralls when entering attics or crawl spaces.
- Wear eye protection and gloves when working in dirty environments, or when working with power tools.
- Wear ear protection when working around insulation blowing equipment.
- Don't carry contaminants home on your clothing.
- Keep dust out of client's homes by erecting temporary barriers from plastic sheeting.
- Use a respirator canister designed for dust.



Personal protective equipment: Employees should maintain protective equipment to protect themselves from hazardous materials.

- Ventilate areas where the foam is being sprayed.
- Work outdoors when applying strong smelling chemicals.
- Learn to recognize asbestos containing materials that may become airborne.
- Learn about the dangers of dust, gases, smoke, vapors, and oxygen-deficient environments.

3.7 Hazardous Materials

Breathing hazardous materials, absorbing them through the skin, and eye contact are common ways workers are exposed to hazardous materials.

E$P agencies must notify and train employees about hazardous materials used on the job. Material Safety Data Sheet (MSDS) must be available for every hazardous material.

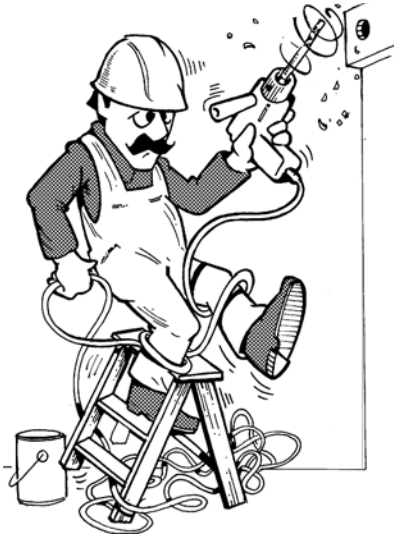
Employees should know:

- Where MSDSs are kept and how to interpret them.
- How to avoid exposure to hazardous materials
- How to clean up chemical spills.
- The appropriate protective equipment to wear when exposed to hazardous materials.

3.8 Falls

Falls from ladders and stairs cause 13% of workplace injuries according to the National Safety Council. Falls from the same elevation such as slips and trips account for approximately 7% of workplace injuries.

Ladder Safety



Ladders: Ladders are the most dangerous tools workers use.

- Do not use broken ladders. Discard them.
- Anchor ladders properly so they can't slip.
- Use the right size ladder for the job.
- Do not stand on the top step or reach too far.
- Extension ladders must extend at least three feet above the roof or landing they access.
- Extension ladders shouldn't have a pitch steeper than four feet of rise for each foot the base is away from the building.
- Ladders must be blocked or tied firmly in place at the top and bottom when the above rule cannot be observed.
- Metal ladders must not be used where they may come in contact with electrical conductors.
- Ladders must be maintained free of oil, grease, and other slipping hazards.
- Ladders must not be loaded beyond the maximum load capacity.
- Workers should avoid carrying heavy loads up ladders.
- Workers should avoid operating power tools from ladders.

Scaffold Safety

- Use scaffolding when working above-ground for sustained time periods.
- Scaffolds should be plumb and level.
- Each leg should be stabilized and support equal weight. This is especially important on uneven ground.
- Planks should be secured to the structure and handrails provided on the sides and ends of the walkway.

Jobsite Cleanup

- Workplaces should be policed regularly to remove slipping and tripping hazards.
- Workers carrying loads should establish a debris-free walkway.

Good housekeeping: Good housekeeping is essential to protect workers and clients alike from falls.

3.9 Tool Safety

Tools are dangerous if used improperly.

- Keep all tools in good condition with regular maintenance.
- Use the right tool for the job.
- Inspect tools for damage before using them.
- Operate tools according to the manufacturer's instructions.
- Provide and use appropriate personal protective equipment (Eye protection, gloves, ear protection).

- Use the correct size wiring with ground-fault interrupter extension cords.
- Stay aware of blades and bits when operating a tool. Keep clear!
- Unplug tools before touching or removing a blade or a bit.

Electrical safety: Cords should be maintained in good condition. Special ground-fault-interrupter cords or outlets should be used in wet conditions.

3.10 Repetitive Stress Injuries

- Use proper posture, hand, and arm coordination in the use of tools or equipment.
- Stretch for just a few minutes several times a day to relieve repetitive stress.
- Use tools that are ergonomically designed.

3.11 Heat Exhaustion

Heat Exhaustion often resembles signs of shock and can include the following symptoms:

Feeling faint

Nausea

Ashen appearance

Rapid heartbeat

Low blood pressure

Hot, red, dry or sweaty skin

Low-grade fever, generally less than 104 F

If you suspect heat exhaustion:

- Get the person out of the sun and into a shady or air-conditioned location.
- Lay the person down and elevate the feet slightly.
- Loosen or remove the person's clothing.
- Have the person drink cool water, not iced, or a sports drink containing electrolytes.
- Cool the person by spraying him or her with cool water and fanning.
- Monitor the person carefully. Heat exhaustion can quickly become heatstroke.

Heatstroke is similar to heat exhaustion, but more serious. Look for:

- Fever - especially greater than 104 F, fainting, confusion or seizures occur, Skin may be hot and dry, although in heatstroke caused by exertion, the skin is usually moist.
- Rapid heartbeat. Rapid and shallow breathing.
- Cessation of sweating. Irritability, confusion or unconsciousness.

If you suspect heatstroke:

- Move the person out of the sun and into a shady or air-conditioned space.
- Dial 911 or call for emergency medical assistance.
- Cool the person by covering him or her with damp sheets or by spraying with cool water. Direct air onto the person with a fan or newspaper.

CHAPTER 4 ENERGY USAGE AND BASELOAD

4.1 EVALUATING ENERGY USE

BASELOAD ENERGY USE

- Water heating, lighting, refrigerator, clothes dryer, and other appliances.
- Potential energy savings by increasing efficiency of these items and improving care in the use of clothes washer, dishwasher, clothes dryer, and lighting.

SEASONAL ENERGY USE

- Heating and cooling.
- Potential energy savings by increasing the thermal efficiency of the building and the delivered efficiency of the heating or cooling system.
- Client behavior can have a large impact on energy savings.

TOTAL ENERGY USE

- Total energy use relates directly to potential energy savings. Homes that use more energy tend to save more energy, and to be more cost-effective to weatherize. Colorado homes typically use 400 to 1200 therms annually for heating.
- If baseload costs are higher, potential savings for doing baseload measures will be higher. If heating costs are higher, savings for heating related measures will be higher. Avoid getting too focused on a single energy-

waste category. Electric baseload varies from around 3500 to 9000 kilowatt-hours per year, not counting water heating. Water heating varies from 2500 to 7000 kWh or 150 to 450 therms depending on family size and client habits.

Table 4-1: Typical Energy Use for Colorado Low-Income Households

Energy User	Annual kWh	Annual Therms
Heating	4000–10,000	400–1100
Water Heating	2000–7000	150–450
Refrigerator	500–2500	n/a
Lighting	500–2000	n/a
Clothes Dryer	500–1500	n/a

To calculate Baseload versus Heating/Cooling for a home with monthly gas and electric billing, perform the following steps.

- Get the energy billing for one full year
- Add the 4 lowest bills together.
- Divide that total by 4.
- Multiply this four-month low bill average by 12. This is the annual baseload energy cost.
- Total all 12 total monthly billings.

- Subtract the annual baseload cost from the total billings. This is the space heating/cooling cost.

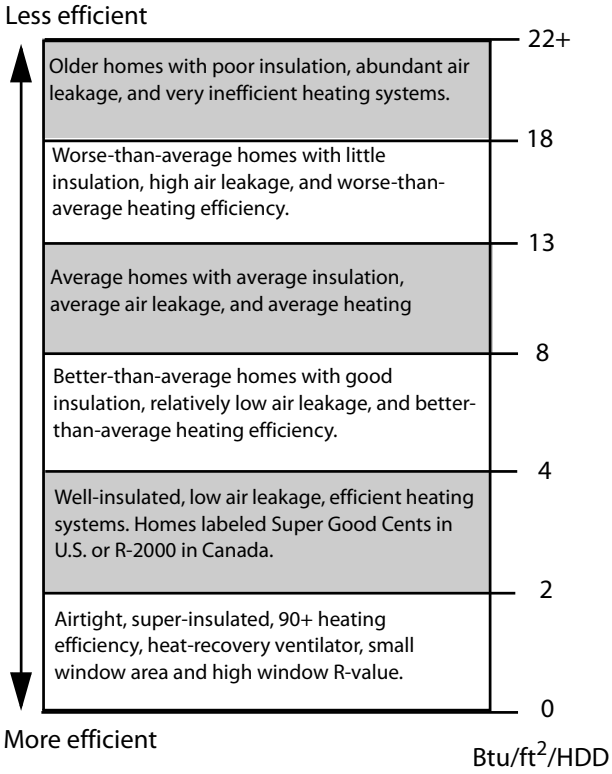
Table 4-2:Separating Baseload from Seasonal Energy Use

Factor and Calculation	Result
Annual total gas usage from utility bills	**1087 therms**
Monthly average gas usage for water heating Average of 4 low months gas usage (19 + 21 + 23 + 22) ÷ 4 = 21.3 therms per month	21.3 therms per month
Annual gas usage for water heating Monthly average usage multiplied by 12 12 x 21.3 = 256 therms per year	**256 therms** per year
Annual heating gas usage Annual total minus annual water-heating usage 1087 – 256 = 831 therms per year	**831 therms** per year
Annual total electric use from utility bills	**6944 kWh**
Monthly average usage for electric baseload Average of 4 low months electricity usage (361 + 372 + 379 + 345) ÷ 4 = 364 kWh per month	364 kWh per month
Annual electric usage for baseload Monthly average usage multiplied by 12 12 x 364 = 4368 kWh per year	**4368 kWh** per year
Annual heating and cooling electrical usage Annual total minus annual baseload usage 6944 – 4368 = 2576 kWh per year	**2576 kWh** per year

Home Heating Index

The Home Heating Index (HHI) is a method of rating a home's heating energy efficiency. If a home has good insulation, low air

leakage and an efficient heating system, its HHI will be low. If the home is inefficient with regard to heating the HHI will be high. The chart and example shown next explain how to compare homes using the HHI.



$$\frac{\textbf{83,000,000 BTUS}}{\textbf{1150 FT}^2\textbf{ X 5500 HDD}} = \textbf{13}\ \frac{\textbf{BTUS}}{\textbf{FT}^2\textbf{ • HDD}}$$

Home Heating Index (HHI), example: The home in the previous table uses 830 therms (or 83,000,000 Btus) for heating, has 1150 square feet of floor space. There are 5500 heating degree days per year where the home is located. Above is the calculation for the HHI and a chart for comparing the HHI of different homes.

4.2 Water-Heating Energy Savings

- ⌘Measure the water heater's water temperature.
- Talk to the client about the potential for scalding if the water temperature is above 130° F.
- Show the client how to set the water temperature, if they want a lower temperature setting. They should set it to the temperature that they feel comfortable with.

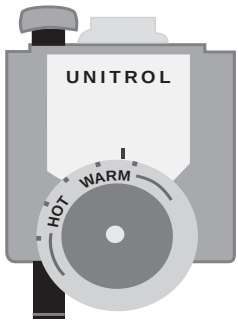
Measuring water temperature

⌘When installing a new water heater you must include a pressure and temperature relief valve and a safety discharge pipe.

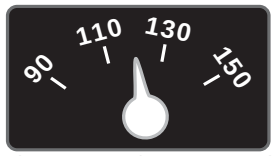
The discharge pipe should terminate 6 inches above the floor or outside the dwelling as specified by local codes. The discharge pipe should be made of rigid metal pipe or approved high temperature plastic pipe.

⌘Hot water leaks must be assessed and repaired if feasible.

Contact the landlord when major plumbing repairs are necessary.



Gas water heater control



Electric water heater control

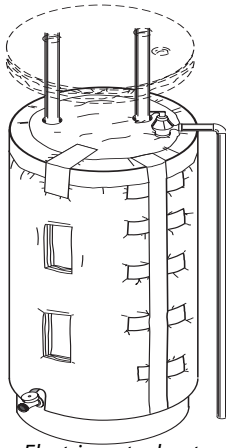
Water-heating Insulation Blankets

⌘Water heaters outside of the living space must be wrapped with blanket insulation, unless:

- The electric water heater is already insulated to R-11 or greater.
- The gas water heater is already insulated to R-7 or greater.
- The water heater label gives specific instructions not to insulate.
- If in doubt about the water tank R-value: put your hand on the tank. If it is warm to the touch, add an insulation blanket.
- Don't cover draft diverters, pressure relief valve, thermostats, high-limit switch, or access plates with the insulation blanket.
- It is not necessary to insulate over the combustion chamber, below the water vessel.
- Do not insulate the water heater if there is no pressure/temperature relief valve, or if there is a vent damper present.
- Use at least two straps to secure the blanket. Do not overly compress the insulation.
- Use at least R-11 blanket material, or the same material used for insulating the foundation.

Gas *water heaters*

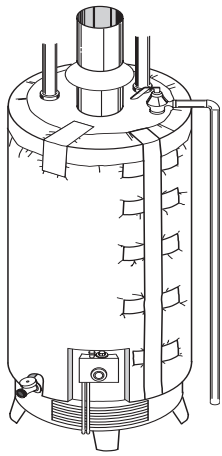
- ⌘Keep insulation at least 2 inches away from the gas valve and the burner access panel.
- ⌘No insulation should be installed below the burner access panel.
- ⌘Do not insulate the tops of gas-fired water heaters.



Electric water heater

Electric water heaters

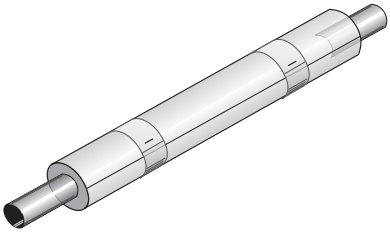
- ⌘Show the client should set both upper and lower thermostats to the same temperature.
- They should shut off power to the water heater before opening any access panels.
- ⌘Cover the water heater's top with insulation.



Gas water heater

- ⌘Cut holes in the blanket to allow access to heating elements and their thermostats.

Hot-Water Pipe Insulation



- ⌘Insulate the first 3 feet of both hot and cold water pipes.
- ⌘Use pipe wrap with a wall thickness of at least $^{5}/_{8}$ inch. Cover elbows, unions and other fittings to same thickness as pipe.
- ⌘Keep pipe insulation at least 6 inches away from combustion vent pipe, unless it has a fire safety rating for 1 inch of clearance.
- ⌘Use the correct size of insulation sleeve for the water pipe diameter.

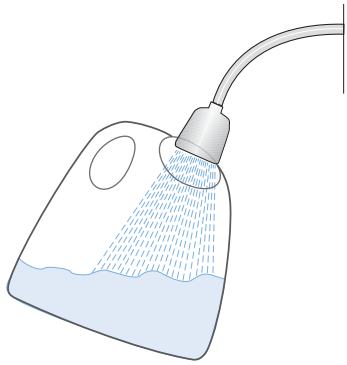
Water-Heater Replacement

- Water heaters with leaking tanks may be replaced for safety reasons.
- Electric water heaters may be converted to gas on an individual basis, with approval from the State. The total replacement cost must be $700 or less.
- Anti-siphon valves should be installed on new water heater installations.

Water-Saving Shower Heads

Shower heads may be replaced with a low flow rate shower head, with the clients permission, if the flow rate is more than 3 gallons per minute.

You can determine flow rate by measuring the time it takes to fill a one-gallon plastic milk jug. If the jug fills in less than 20 seconds, your flow rate is more than 3 gallons per minute.



Measuring shower flow rate

4.3 Appliances and Lighting

Refrigerator Assessment and Replacement

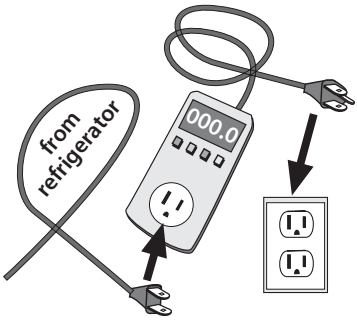
General Requirements

- ⌘All refrigerators must be evaluated for replacement.
- ⌘The results of the evaluation must be documented in the client file.
- ⌘Only operating refrigerators and refrigerator -freezers may be replaced.
- ⌘Refrigerators may only be replaced with a new refrigerator that meets the cost-effective criteria (SIR).
- ⌘The economic life of replacement refrigerators in the computer audit must be entered as 15 years. The SIR must be entered as 1.2. All refrigerators being replaced must have an SIR of 1.2 or higher.

- ⌘Eligible refrigerators that are not metered must be analyzed with the NEAT computer audit, or other DOE approved methodology.
- ⌘All eligible refrigerators whose manufacture information cannot be determined must be metered.
- ⌘Eligible refrigerators are those functioning appliances that meet the SIR criteria for replacement, and can reasonably be accessed for removal and replacement.
- ⌘The owner of eligible refrigerators must sign the E$P Refrigerator Replacement agreement, and must comply with the terms of that agreement, including relinquishing ownership of the old appliance at the time of delivery of the new appliance. Landlords who own eligible refrigerators must contribute 50% of the total cost of replacement.
- ⌘Agencies must meter at least 10% of the refrigerators that are replaced. The minimum time duration of the metering is a two hour period, uninterrupted by a defrost cycle. If the defrost timer cannot be advanced, a meter capable of detecting the defroster run time must be used to meter for a minimum of 3 hours.
- ⌘Agencies must retain in the client file the E$P Terms and Conditions for Refrigerator Replacement form. The form must be signed and dated by the appliance owner and the agency representative.
- ⌘Agencies must retain in the client file information from the existing refrigerator detailing the make, model number, size, age, kilowatt hour usage, and if it was metered or found in the AHAM database.
- ⌘The make and model of the new refrigerator must also be retained in the client file.
- ⌘Agencies may use all or part of the $150 per home repair waiver toward correcting problems associated with refrigerator replacement.

Metering Protocol

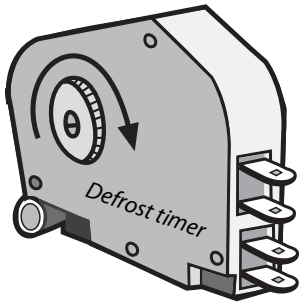
Read and follow the metering instructions for your particular kilowatt (kWh) meter.



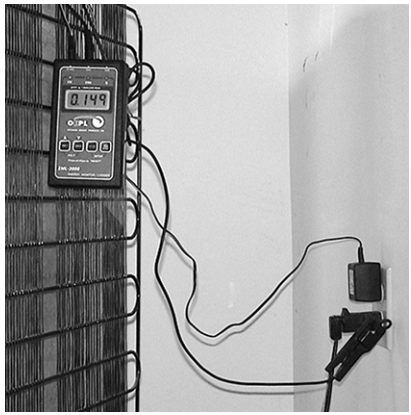
⌘A minimum of 10% of replacements must be metered. Those in which the manufacture information cannot be determined must be metered.

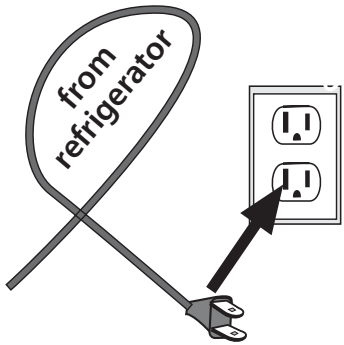
- ⌘The metering period is a minimum of two (2) hours.
- ⌘The defrost cycle must not activate during short term metering. Therefore it is necessary to de-activate the defrost timer before starting to meter.
- ⌘Locate the defrost timer (usually inside a removable mounting box) on the back of the appliance, inside refrigerator next to the light panel, or behind the bottom front kick-plate.
- ⌘Advancing the defrost timer is not necessary if your equipment is capable of accounting for and removing electricity used during the defrost cycle. In this case the metering period is a minimum of three (3) hours.
- ⌘Check the electrical outlet to make sure that it is grounded and that the voltage is adequate.
- ⌘If the outlet is not grounded, check to see if the outlet box is grounded. If it is, it will be possible to ground the outlet to the box. A three prong adapter with a ground wire that is grounded to the box may also be used.

- Some plug-load meters and software provide for removal of the defroster spike. If you are correctly using a meter with this capability, it is not necessary to advance the defrost timer.



- ⌘Advance the defrost timer manually using a screwdriver and turning the pinion clockwise (do not turn counter-clockwise this may damage the timer) until you hear a loud click (this is the beginning of the defrost cycle) continue to turn clockwise unit you hear a loud second click (this is the end of the defrost cycle) you are now ready to begin short term metering.





- If you experience any problems metering an appliance contact your supervisor immediately.
- ⌘Document all pertinent information on the proper forms.

- ⌘Use the refrigerator replacement chart or approved software to determine if it is cost effective to replace the refrigerator.
- **⌘Plug the refrigerator back into its outlet.**

Tool list

1. Electrical circuit analyzer (Sure-Test or equivalent)
2. kWh plug-load meter
3. Pen/pencil and Refrigerator Replacement Form
4. Flashlight and pocket calculator
5. 3 to 2 way electrical adaptor
6. A piece of carpet or cardboard for moving the appliance

Client responsibilities

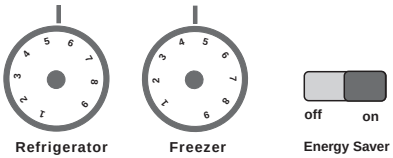
⌘Agencies must ensure compliance with the following:

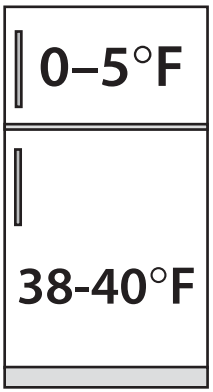
- An adult must be present (over 18 years age) at time of delivery to sign for receipt of the new refrigerator.
- The client must empty the old refrigerator of all foods and create a clear path for removal and delivery of the appliances.
- The client must have a phone, or access to a phone for scheduling.
- The client is responsible for cooling of any foods during the first 24 hours (stabilization period) after delivery of the new refrigerator.
- Appliances scheduled for pick-up and removal must be available at the time of delivery, or the delivery of the new refrigerator will not be made.
- Families may not keep their old refrigerators. The old refrigerator must be removed when the new appliance is delivered.

- Landlords will be responsible for a co-payment of 50% of total costs before the order will be placed.

Refrigerator Operating

Consider these operating tips to save energy and money on refrigeration:



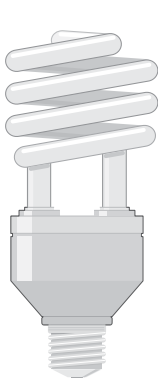


- Using a thermometer, measure refrigerator and freezer temperature. If the refrigerator temperature is less than 38° F, or freezer temperature is below 0° F, adjust the dials inside the refrigerator until the thermometer reads 38–40° F for the refrigerator and 0–5° F for the freezer.
- Activate the 'energy saver' switch, which turns off the heaters around the refrigerator door, unless frost forms on the door seals.
- Clean refrigerator condenser coil to increase airflow through coils.
- Encourage clients to avoid operating two refrigerators. Instead, use one larger model.

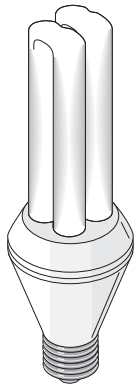
Lighting Assessment and Replacement

- Ask the client about their lighting usage.
- Explain the electrical savings potential for switching to compact fluorescent lighting (CFL).
- Incandescent lighting that is used regularly for two or more hours per day may be replaced with compact fluorescent lighting.
- Demonstrate a CFL bulb to the client if they are unsure about replacing their incandescent light bulbs.
- There are several CFL bulb types. Select higher wattage bulbs where more lighting is needed.

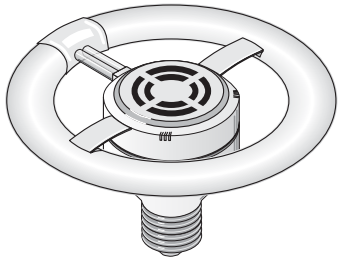
Fluorescent torchiere



Spiral



Quad



Circline

CHAPTER 5 COMBUSTION APPLIANCE

5.1 COMBUSTION REQUIREMENTS

- ⌘Combustion appliances must operate in a safe and reasonably efficient manner.
- ⌘E$P combustion appliance procedures must be followed.
- ⌘There must be no spillage into the living space of the home at five minutes into the combustion cycle.
- ⌘Carbon monoxide in the undiluted flue gas must not exceed 250 ppm.
- ⌘There must be no fuel leaks.
- ⌘Flex connectors that are damaged or older than 1973 must be replaced.
- ⌘Duct sealing procedures must be followed.
- ⌘Low-efficiency furnaces must be assessed for replacement with high efficiency furnaces as an E$P measure.
- ⌘Determine as quickly as possible if the furnace will be replaced.
- ⌘If the furnace will be replaced, check for and correct only those safety issues which pose an immediate threat to the client.

5.2 E$P Combustion Appliance Procedures

⌘Initial Assessment

1. Ask the client if they have any problems with the furnace or water heater.
2. Document existing conditions, any work done, and test results.
3. Determine if the furnace should be replaced or needs follow up work.
4. Check duct supply and return grilles and make sure that their airflow is not blocked by furniture or other obstacles.
5. Measure the domestic hot water temperature and discuss the potential for saving energy by setting back the thermostat and for reducing the water temperature.

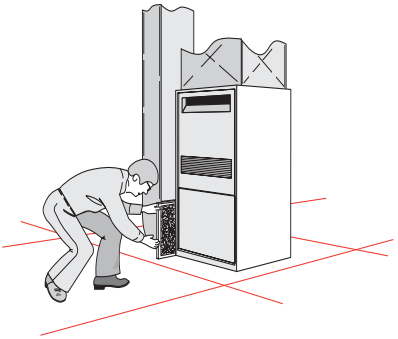
6. Go to the furnace. Check the fuel supply lines for leaks. If significant fuel leaks are found, contact your supervisor for further instructions.

7. Inspect the flexible gas connectors on all combustion appliances. Flexi-

ble connectors that are leaking, damaged, kinked, or manufactured prior to 1973 must be replaced.

8. Complete a visual inspection of the interior of the heat exchanger for cracks. Stop if you see any cracks in the heat exchanger and **contact your Supervisor.**

9. Inspect the combustion venting systems of all combustion appliances. If the combustion venting systems are not intact, or are causing or allowing combustion vent gases to enter the building, repairs to the systems must be completed.



10. Check the draft hood and heat exchanger(s) of space and water heating appliances for carbon build-up.

11. Remove filthy and clogged furnace filters. Provide and have the client install the new filter, if they're willing to do it. If the client isn't willing or able, leave the new filter near the furnace.

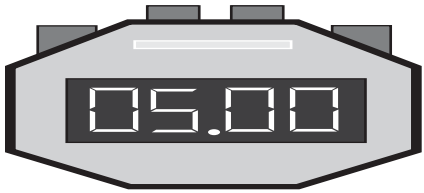
12. Clean filthy and clogged blowers and air handlers.

13. Assess and seal ductwork as necessary to comply with the duct-sealing procedures described on page 114.

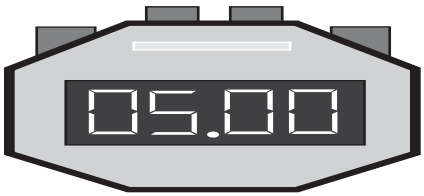
Safety Tests

14. Close all exterior doors, windows, and access hatch covers. Turn on all exhaust appliances. Fully open all

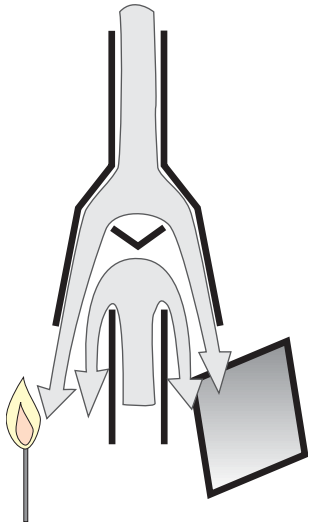
supply and return registers that are normally open during the heating season.



15. Fire the furnace. Check your watch or start a timer.
16. Close the door behind you as you enter the room where the combustion appliances are located.
17. If the water heater is gas fired, mark the existing temperature setting and then increase the temperature setting until the main burner ignites.
18. Inspect furnace main burner flames before and after the air handler is running. Flames should be stable and contain no white coloring in their tips.



19. After about 5 minutes, or before the burner shuts off, check for carbon monoxide and spillage.

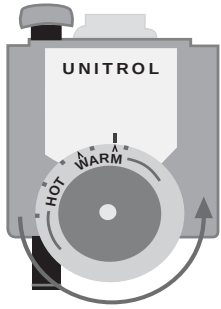


Spillage and CO tests:

20. Pass a lighted match or mirror around the relief opening of the draft hood on the furnace and water heater. If the match is extinguished or the mirror fogs, the appliance is spilling. **Stop your work if there is a**

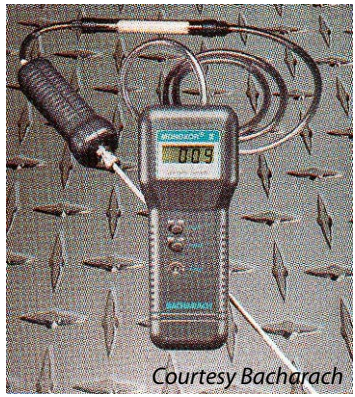
significant amount of spillage and you cannot solve the problem. Contact your supervisor.

21. CO is normally tested at the exhaust port of the heat exchanger.
22. Appliances without draft hoods may be tested in the vent pipe or at the vent termination.
23. If the water heater has not been tested, complete all applicable safety tests on the water heater now.
24. After completing all safety tests, turn the combustion appliances off.
25. Educate the client on how to set the water heater temperature and how to change the furnace filter.
26. Inform your supervisor of all problems that need correction.



Set water temperature back to 125° F and mark

5.3 Background Information

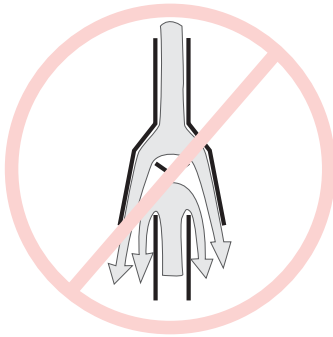


Courtesy Bacharach

Causes of CO

CO in combustion appliances is usually caused by one of the following:

- Overfiring
- Backdrafting of combustion gases smothering the flame
- Flame interference by an object (a pan over a gas burner on a range top, for example)
- Flame interference by moving air
- Misalignment of the burner
- Inadequate combustion air in tight, confined spaces.



Gas Leak Detection

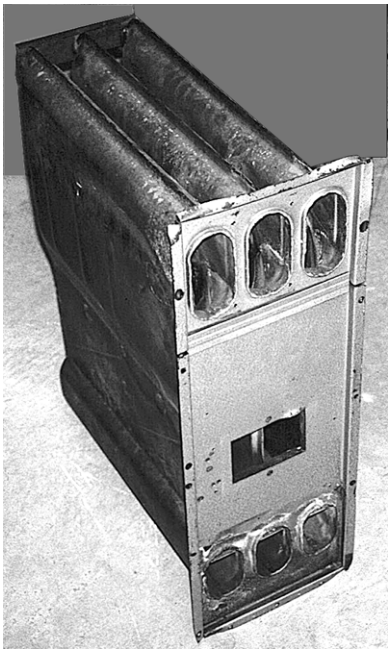
Natural gas and propane piping systems may leak at their joints and valves. Find gas leaks with an electronic combustible-gas detector, often called a gas sniffer. A gas sniffer will find all significant gas leaks if used carefully. Remember that natural gas rises from a leak and propane falls, so position the sensor accordingly.

- Sniff all valves and joints with the gas sniffer.
- Accurately locate leaks using a non-corrosive bubbling liquid, designed for finding gas leaks.
- All gas leaks should be repaired.
- Replace kinked or corroded gas flex connectors.
- Replace gas flex connector made before 1973.

Inspecting Heat Exchangers

Cracks in heat exchangers are a problem because they allow the blower fan air pressure to move the combustion flame, and possibly to force flue gases out of the furnace and into the home. Minor defects in the manufacture of the heat exchanger are not an acceptable reason to replace the appliance with E$P funds. Ask clients about respiratory problems, flue-like symptoms, and smells in the house when the heat is on.

- Look for flame-damaged areas near the burner.
- Look for flame impinging against the heat exchanger during firing.
- Look for rust at furnace exhaust and vent connector.
- Observe flame movement, or change in CO reading as air handler is turned on and off.
- Examine the heat exchanger, shining a bright light on one side and looking for light traces on the other using a mirror or inspection scope to peer into tight locations.



Gas-furnace heat exchanger

Advanced Combustion Appliance Procedures

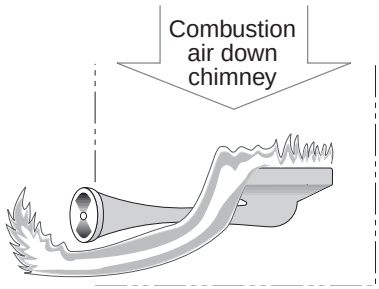
Advanced procedures may only be performed by qualified furnace technicians. Furnace efficiency modifications are rarely cost effective and should only be undertaken in extreme situations.

Gas Burner Safety

The goal of these measures is to reduce carbon monoxide (CO), stabilize flame, and verify the operation of safety controls.

Proceed with burner maintenance and adjustment when:

- CO is greater than 250 ppm.
- Visual indicators of soot or flame roll-out exist.
- Burners are visibly dirty.
- There is visual evidence of spillage at the combustion port.



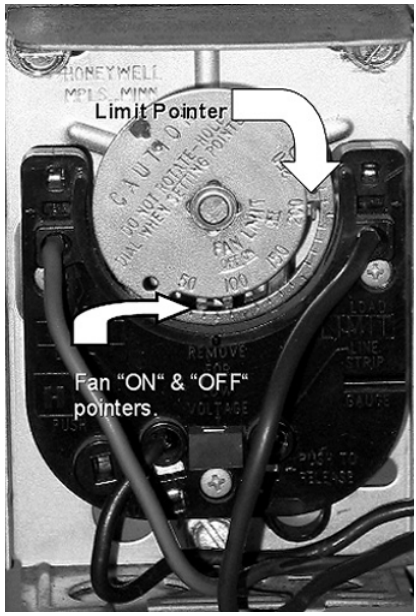
Flame roll-out

Gas-burner maintenance includes the following measures.

- Remove causes of CO and soot, such as over-firing, closed primary air intake, flame impingement, and lack of combustion air.
- Remove dirt, rust, and other debris that may be interfering with the burners. Clean the heat exchanger, if necessary.
- Take action to eliminate spillage, caused by depressurization, improper venting, obstructed chimney, or leaky chimney.

- Seal leaks in vent connectors and chimneys.

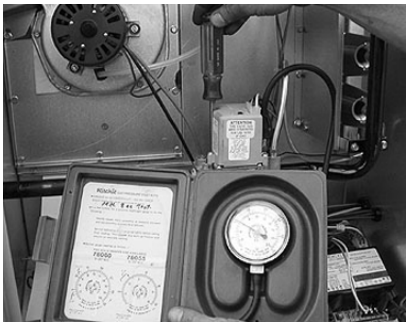
Setting the Fan Switch



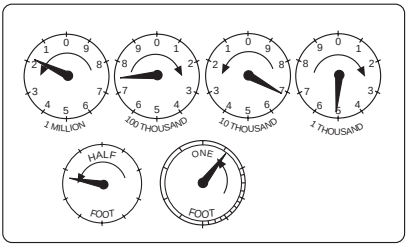
- If the house side blower shuts off at a temperature above 95°F, no more than three (3) attempts shall be made to obtain acceptable fan-off (and fan on) temperatures.
- Setting the limit switch to a higher temperature is allowable if the furnace is cycling on the limit. Care should be taken to ensure that the limit switch is indeed set too low, and that the new set temperature is not too high.

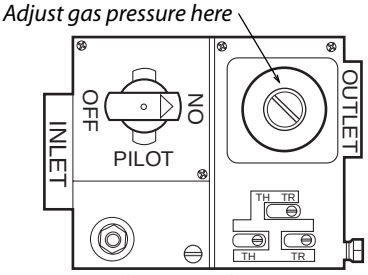
Measuring BTU input on natural gas appliances

Use the following procedure when it's necessary to measure the input of a natural gas appliance.



Gas-pressure manometer





Modern gas valve top view

- Turn off all gas combustion appliances such as water heaters, dryers, cook stoves, and space heaters that are connected to the meter you are timing, except for the appliance you wish to test.
- Fire the unit being tested, and watch the dials of the gas meter.
- Carefully time how long it takes for one revolution of $^1/_2$, 1, or 2 cubic-foot dial.
- Find that number of seconds in *Table 5-1* in the columns marked "Seconds per Revolution." Follow that row across to the right to the correct column for the $^1/_2$, 1, or 2 cubic-foot dial.
- Note that you must multiply the number in the table by the Btu content of one hundred cubic feet of natural gas.
- Record the input in thousands of Btus per hour.
- Adjust gas pressure by turning the regulator-adjustment screw located underneath a screw-on cap on the gas valve.

Table 5-1:Input in Thousands of Btu/hr for 1000 Btu/cu. ft. Gas

Seconds per Revolution	Size of Meter Dial			Seconds per Revolution	Size of Meter Dial			Seconds per Revolution	Size of Meter Dial		
	1/2 cu. ft.	1 cu. ft.	2 cu. ft.		1/2 cu. ft.	1 cu. ft.	2 cu. ft.		1/2 cu. ft.	1 cu. ft.	2 cu. ft.
15	120	240	480	40	45	90	180	70	26	51	103
16	112	225	450	41	44	88	176	72	25	50	100
17	106	212	424	42	43	86	172	74	24	48	97
18	100	200	400	43	42	84	167	76	24	47	95
19	95	189	379	44	41	82	164	78	23	46	92
20	90	180	360	45	40	80	160	80	22	45	90
21	86	171	343	46	39	78	157	82	22	44	88
22	82	164	327	47	38	77	153	84	21	43	86
23	78	157	313	48	37	75	150	86	21	42	84
24	75	150	300	49	37	73	147	88	20	41	82
25	72	144	288	50	36	72	144	90	20	40	80
26	69	138	277	51	35	71	141	94	19	38	76
27	67	133	267	52	35	69	138	98	18	37	74
28	64	129	257	53	34	68	136	100	18	36	72
29	62	124	248	54	33	67	133	104	17	35	69
30	60	120	240	55	33	65	131	108	17	33	67
31	58	116	232	56	32	64	129	112	16	32	64
32	56	113	225	57	32	63	126	116	15	31	62
33	55	109	218	58	31	62	124	120	15	30	60
34	53	106	212	59	30	61	122	130	14	28	55
35	51	103	206	60	30	60	120	140	13	26	51
36	50	100	200	62	29	58	116	150	12	24	48
37	49	97	195	64	29	56	112	160	11	22	45
38	47	95	189	66	29	54	109	170	11	21	42
39	46	92	185	68	28	53	106	180	10	20	40

If the measured input is higher or lower than input on the name plate by more than 10%, adjust gas pressure up or down within a range of 3.2 to 3.9 IWC.

- If the measured input is still out of range, replace the existing orifices with orifices sized to give the correct input.

Table 5-2:Combustion Problems and Possible Solutions

Problem	Possible causes and solutions
Spillage or weak draft with CAZ depressurization	Return duct leaks, clothes dryer, exhaust fans, other chimneys. Seal return leaks. Provide make-up air.
Spillage or weak draft with no CAZ depressurization	Chimney defect. Or CAZ is too airtight.
Heat rise too high or low	Adjust fan speed. Adjust gas input. Improve ducts to increase airflow.
Carbon monoxide or soot	Mixture too rich or too lean. Adjust gas input. Clean airways, burners, and heat exchanger. Check chimney and combustion air for code compliance.

Table 5-3:IFGC-Approved Combustion Air Openings

Location	Dimensions
Two direct openings to adjacent indoor space	Minimum area each: 100 in^2 1 in^2 per 1000 Btuh each Combined room volumes must be Š 50 ft^3/1000 Btuh
Two direct openings or vertical ducts to outdoors	Each vent should have 1 in^2 for each 4000 Btuh
Two horizontal ducts to outdoors	Each vent should have 1 in^2 for each 2000 Btuh
Single direct or ducted vent to outdoors	Single vent should have 1 in^2 for each 3000 Btuh
Location and Size from the International Fuel Gas Code	

Heat Rise Flow Chart

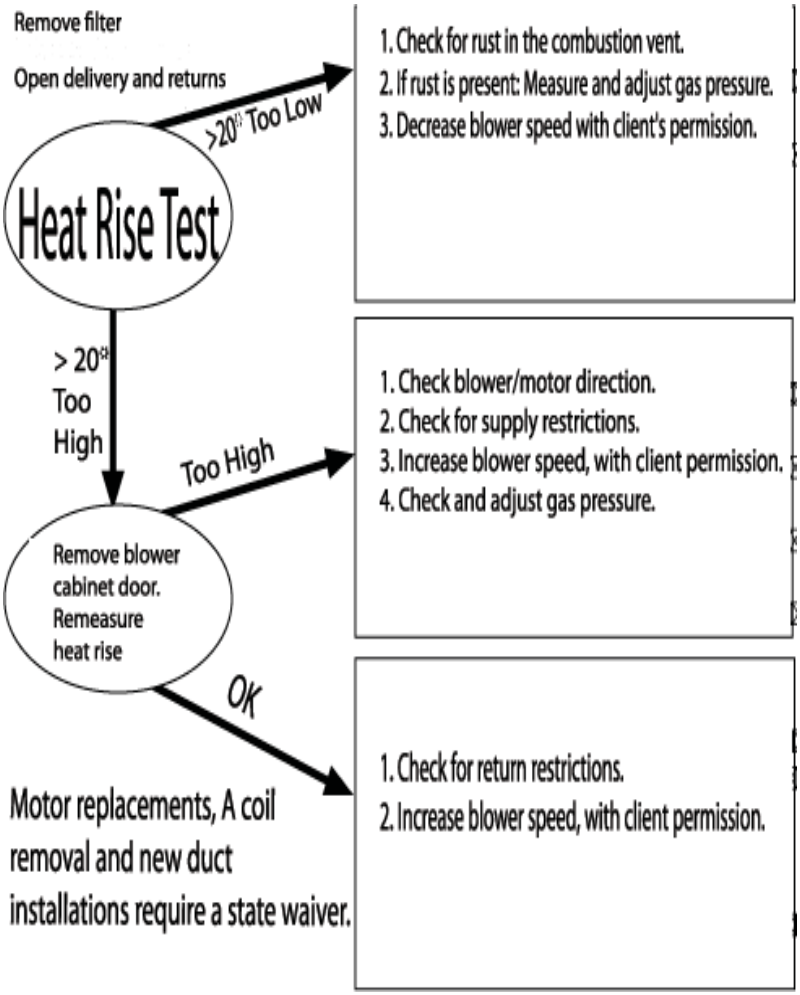


Table 5-4:Spillage Problems and Solutions

Problem	Possible Solutions
Continuous spillage	Remove chimney blockage, seal chimney air leaks, or provide additional combustion air as necessary.
Blower activation initiates spillage	Seal leaks in the furnace and in nearby return ducts. Isolate the furnace from nearby return registers.
Exhaust fans initiate spillage	Provide make-up or combustion air if opening a door or window to outdoors strengthens draft during testing.
Closing interior doors during blower operation initiates spillage	Add return ducts, grills between rooms, or jumper ducts.

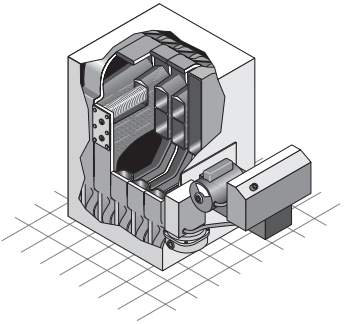
5.4 Boiler Efficiency and Maintenance

- ⌘Check system pressure and gauges before firing the boiler. Do not fire the system if the pressure is greater than 30 psi.
- ⌘A five minute combustion safety test must be performed.
- ⌘Boilers must not produce CO in excess of 250 ppm when measured in the vent pipe, before dilution.
- ⌘Boilers must not spill combustion products into the living space.
- ⌘All hydronic heating system water pipes that are outside the living space of the unit must be insulated with minimum 1/2"-thick, properly sized, temperature rated insulation.
- Hydronic heating system pipes may be insulated within the living space if it is determined that the space does not need to be heated or is overheated.
- ⌘Heating system pipe insulation must have mitered cuts at elbows. Pipe insulation must be properly secured.
- ⌘A visual inspection of the system must be performed. Large water leaks, major mechanical problems, and defective zoning to intentionally heated space must be corrected.
- Optional boiler work must be performed by a qualified technician, and may only be performed where warranted.

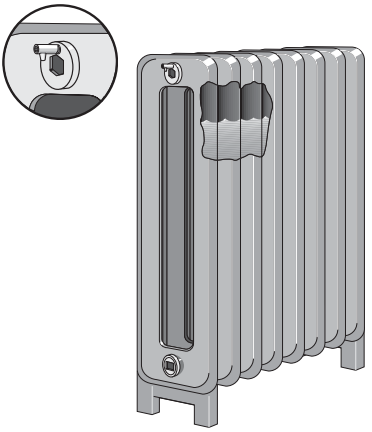
Optional boiler performance and efficiency improvements

- Check the expansion tank. If it is water logged, replace it.

- Check for leaking air or steam vents. Replace bad vents.
- Drain water from the boiler drain until the water flows clean.
- Make sure the water flow and direction is correct for the boiler.
- Purge air from the system.
- Clean the fire side of the heat exchanger.
- Adding an electrical vent damper is an allowable measure.
- Check for water leaks and fix them.
- Check and set the aquastat temperature. 180 degrees faranheit is recommended.
- Check for constant temperature control and convert to on demand.
- Remove side arm DHW heaters and install a stand alone system.



Cast-iron sectional boiler



Air in radiators: Radiators lose heating capacity when partially full of air.

- Check zone valve operation and repair faulty zone valves.

- Set anticipator to highest setting.

Pressure tank, air separator, and vent

Zone valves

Chapter 6 Building Shell

General Requirements

- ⌘All work must be complete, of good quality, and must have a good appearance if it is in a location that is normally seen.
- ⌘Air leakage and insulation work must be done at the thermal boundary.
- ⌘The insulation work must be done in a manner that creates as continuous a conductive boundary as possible.
- ⌘Cost-effective guidelines must be followed.
- ⌘Technical waivers must be reasonable and appropriate.

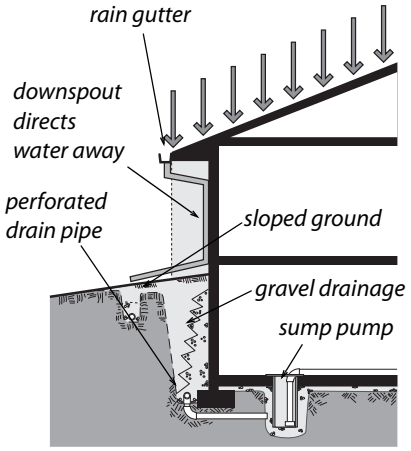
Thermal Boundary

It is very important to understand where the thermal boundary is located. This is where most of the building shell measures are installed. On one side of the boundary is the space that is being heated in the winter, and on the other side it is cold in the winter.

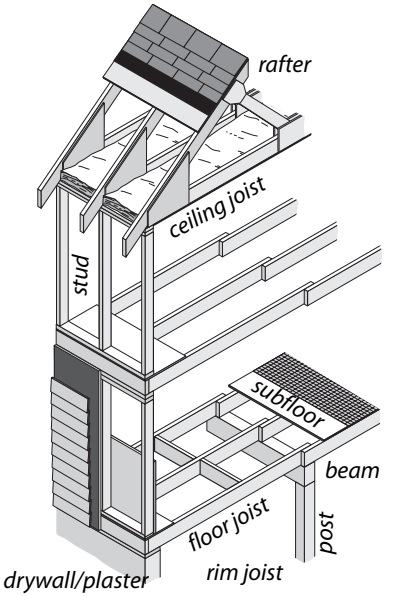
Insulation gaps and air leaks at the thermal boundary allow heat to be wasted. The job of the Building Shell Technician is to seal the leaks and fill the gaps so that there is as complete a boundary as possible.

Correcting Moisture Problems

- ⌘*Vent clothes dryers outside the building.*
- ⌘*Correct moisture and drainage problems that can affect weatherization measures or client health.*
- Repair leaky gutters.
- Extend downspouts.
- Talk to the client about opening a window or operating ventilation fans when producing moisture.
- Add or repair mechanical ventilation so that fans exhaust moisture to the outdoors.
- Add a sump pump if there is a high water problem in the crawl space or basement and there is an existing pit and electrical connection.



Stopping water intrusion: A variety of measures can protect homes from water intrusion.



Installing a ground moisture barrier

- ⌘Install a 6 mil polyethylene plastic vapor barrier in all crawlspaces where the earth is not loose and dry.
- ⌘Overlap the seams at least 12 inches.
- ⌘Use U shaped tent stakes driven into the ground, rocks, or debris to secure the plastic.

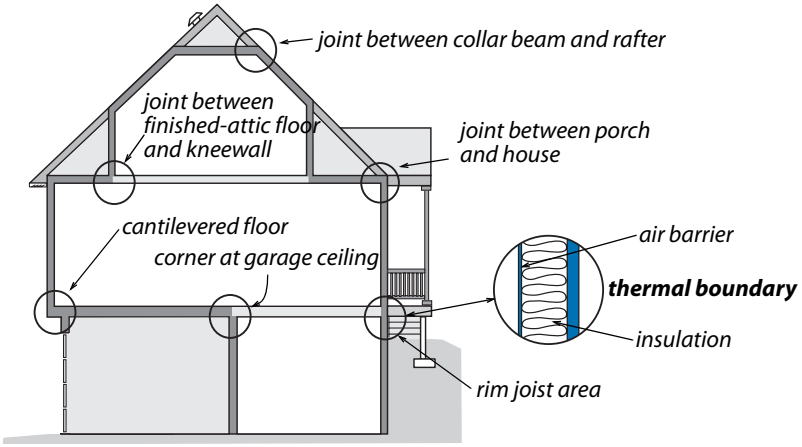
If there is evidence of moisture coming through the foundation wall:

- Staple plastic vapor barrier material or an insulation blanket that has been wrapped in 6ml plastic to the mud sill.
- The plastic must protect the foundation insulation from moisture coming through the foundation wall.
- Lay the ground vapor barrier so that it covers all exposed soil.

Air Sealing

- ⌘Air sealing building shells in a cost-effective manner is required.
- Much of the air sealing work that is needed can be done as the insulation prep work is done. Adding wall insulation will often reduce air leakage.
- The auditor should have a drawing of the thermal boundary or explanation of where the thermal boundary has been established, in the file.
- ⌘Do air sealing work and do insulation prep at the thermal boundary.
- ⌘Run the blower door continuously, or check for air leakage reductions regularly while air sealing.

- ⌘Run the blower door to find air leaks. Follow cost-effective guidelines while sealing air leaks.

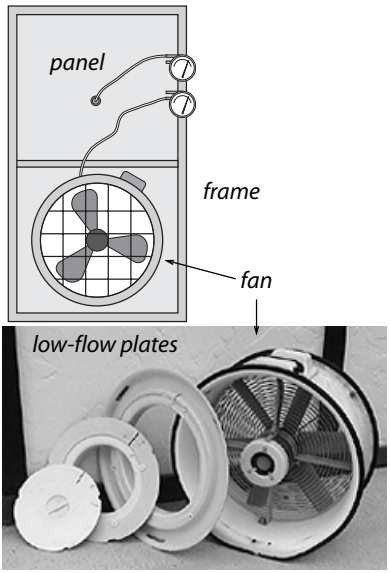


Thermal boundary flaws: The thermal boundary contains the air barrier and insulation, which should be adjacent to one other. The insulation and the air barrier are often discontinuous at corners and transitions. These areas merit special attention.

- Seal air leaks; use caulk, fiberglass insulation batts, foam, Celotex, plywood, etc. as necessary and appropriate for the area where you are sealing.
- ⌘Seal bypasses (chases, open top plates) that are one square foot or larger. Blow cellulose insulation material into the opening or seal it with plywood, sheetrock, foil ray, sheet metal, insulation batts and other appropriate materials.
- Note: Bypass sealing may not result in reducing blower door readings, but will reduce heat loss that occurs when warm interior surfaces are exposed to cold air.

6.1 Blower-Door Testing Procedures

The blower door creates a 50-pascal pressure difference across the building shell and measures airflow in cubic feet per minute at 50 Pascals (CFM_{50}), in order to compare the leakiness of homes. The blower door also creates pressure differences between rooms in the house and intermediate zones like attics and crawl spaces that can give clues about the location and size of a home's air leaks.



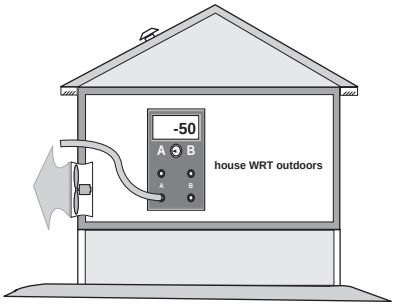
Preparing for a Blower-Door Test

- Identify location of the thermal boundary and which house zones are conditioned.
- Identify and repair large air leaks that could prevent the blower door from achieving adequate house pressure.
- Survey pollutants that may pollute the air during a blower door test—wood-stove or fireplace ashes for example.
- Cover ashes with wet newspapers.
- Do not run the blower door if there is a wood fire, or other potential problem.
- Close fireplace dampers.
- Turn combustion appliance gas valves to the pilot setting.

- Put the house in its heating and/or cooling mode with windows, doors, and vents closed and air registers open.
- Turn off combustion appliances temporarily.
- Open interior doors so that all indoor areas inside the thermal boundary are connected to the blower door.
- Ensure children and pets are at a safe distance from fan blades.
- Connect the manometer's hoses correctly.

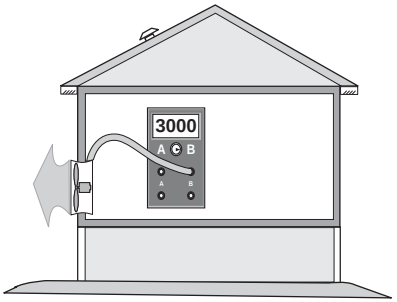
"With reference to" (WRT) input zone to reference zone.

The outdoors is the most common reference zone, the heated space the input zone. This is the house WRT outdoors pressure difference.



Blower door test: Air barriers are tested during a blower-door test, with the house at a pressure of 50 pascals negative with reference to outdoors. This house has 3000 CFM_{50} of air leakage. Further diagnostic tests can help determine where that leakage is coming from.

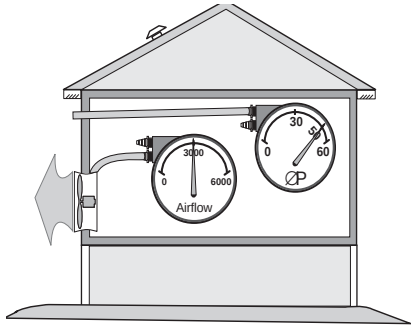
Tighter buildings require the use one of two or three low-flow plates. When using one of these low-flow plates, you must read the correct scale on the analog gauges. When using a digital gauge, follow the manufacturer's instructions for selecting the proper fan configuration corresponding to the correct low flow plate.



Some homes are so leaky that the blower door isn't powerful enough to depressurize them to –50 pascals. In these cases, begin air sealing large air leaks.

Blower Door Set Up

- Install blower door frame, panel, and fan in an exterior doorway with a clear path to outdoors.
- On windy days, place the blower door in a doorway that is parallel to the wind, if possible.
- Run the pressure tap hose at least 5 feet out and to the side of the blower fan.
- Open all interior doors.
- Close all windows and exterior doors.



Analog manometers: The airflow manometer's low-pressure port is connected to the fan. The house-pressure manometer's high-pressure port is connected to outdoors for depressurization.

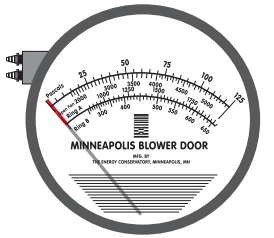
- Follow manufacturer's instructions for fan orientation and manometer setup for either pressurization or depressurization.
- Connect the house-pressure manometer to measure house WRT outdoors.
- Connect the airflow manometer to measure fan WRT zone near fan inlet. The zone near the fan inlet is indoors for depressurization and outdoors for pressurization.
- Set all gas valves to "pilot", turn thermostats down, and gas cooking appliance controls to "off" while running the blower door.
- When testing is complete, relight pilots as necessary and Turn gas valves back to "on" position and set thermostats back to their original temperature setting.

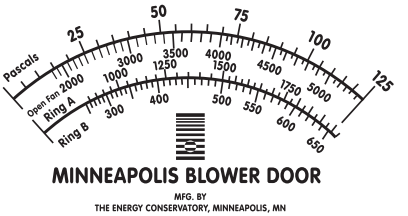
Zeroing Blower Door Manometers

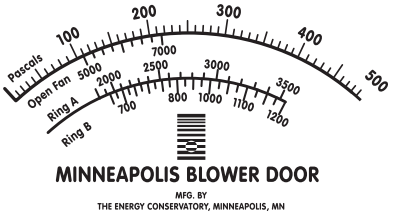
Analog manometer:

- Block the blower door's opening.
- Make sure that the house-pressure hose is connected to outdoors and that the fan hose is disconnected.
- Tap each gauge face with your finger to make sure that the needle isn't stuck.
- Use the adjustment screw on the face of the dial to set the needle at exactly zero.

high pressure
low pressure

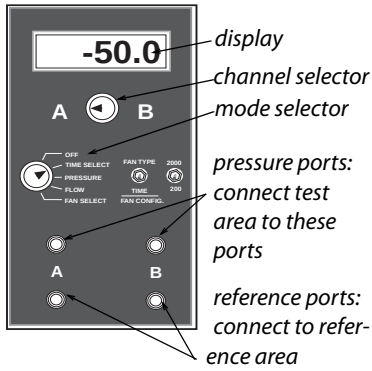






Digital manometer:

- Block the blower door's opening.
- Make sure that the house-pressure hose is connected to outdoors and that the fan hose is disconnected.
- Measure the house pressure with the blower door off.
- If you read a positive house pressure of a few pascals, add those pascals to 50 pascals and run the blower door at that pressure.
- If you read a negative pressure than subtract those pascals from 50 pascals, and run the blower door at that pressure.



Digital manometers: Used to diagnose house and duct pressures quickly and accurately.

Using the Blower Door

- Turn on the fan and increase its speed until you read 50 pascals.
- Use the blower door to locate air leaks.
- Track air leakage reductions once each hour of air sealing.
- Record reductions in the audit form.
- Stop sealing when it is no longer cost-effective.

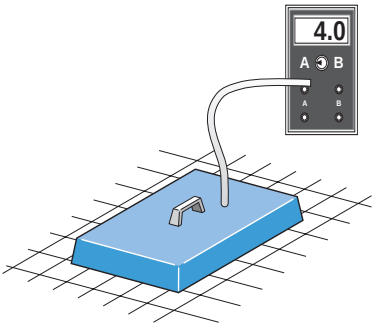
See Table 6-1 on page 111.

Checking for duct leakage

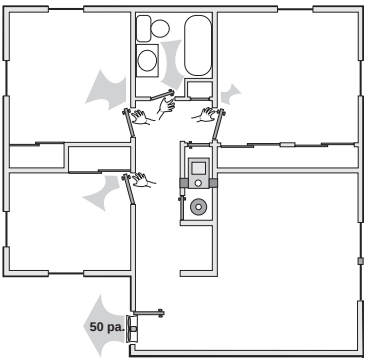
- Use pressure pan, smoke, or feel for air movement with your hand while running the blower door.

Investigate the shell for air leaks

- Close interior doors, one at a time.
- Feel for pressure as the door closes.
- Check for air leakage reduction with the door closed.
- Pressurize the house and look for leaks from the attic or in along the exterior of the foundation.



Pressure pan: Blocks a single register and measures the air pressure behind it, during a blower door test. The magnitude of that pressure is an indicator of duct leakage.



Interior door test: Feeling airflow with your hand at the crack of an interior door gives a rough indication of the air leakage coming from the outdoors through that room.

Post Blower-door Test Essentials

- Be sure to return all temporary measures, taken to facilitate the blower door test, to their original condition.
- Reset all gas valves to their normal position.
- Reset thermostats of heaters and water heaters that were turned down for testing.
- Remove temporary plugs, installed to increase house pressure, and make air seals permanent.

Approximate leakage area

There are several ways to convert blower-door CFM50 measurements into square inches of total leakage area. The simplest way to convert CFM50 into an approximate leakage area (ALA) is to divide CFM50 by 10. The ALA can help you visualize the size of openings you're looking for in a home or section of a home.

Table 6-1:Air-Sealing Cost-Effectiveness

$/therm	4000	5000	6000	7000	8000	9000	10,000	11,000	
$0.44	$15	$18	$22	$26	$29	$33	$37	$41	Natural Gas
$0.46	$15	$19	$23	$27	$31	$35	$39	$42	
$0.48	$16	$20	$24	$28	$32	$36	$40	$44	
$0.50	$17	$21	$25	$29	$33	$38	$42	$46	
$0.52	$17	$22	$26	$31	$34	$39	$44	$48	
$0.54	$18	$23	$27	$32	$36	$41	$45	$50	
$0.56	$19	$23	$28	$33	$38	$42	$47	$52	
$0.58	$19	$24	$29	$34	$39	$44	$49	$54	
$0.60	$20	$25	$30	$35	$40	$45	$50	$55	
$0.75	**$25**	**$31**	**$38**	**$44**	**$50**	**$57**	**$63**	**$69**	
$1.00	$34	$42	$50	$59	$67	$75	$84	$92	Propane
$1.25	$42	$52	$63	$73	$84	$94	$105	$115	
$1.50	$50	$63	$$75	$88	$101	$113	$126	$138	
$1.75	$59	$73	$88	$103	$117	$132	$147	$161	
$2.00	**$67**	**$84**	**$101**	**$117**	**$134**	**$151**	**$168**	**$185**	
$2.25	$75	$94	$113	$132	$151	$170	$189	$208	Elec.
$2.50	**$84**	**$105**	**$126**	**$147**	**$168**	**$189**	**$210**	**$231**	

Maximum recommended expenditure for reducing 100 CFM_{50} for homes with furnaces standing pilots. Assumes labor cost of $15 to $20 per hour, including labor.

Building Tightness Limits (BTL)

Experience in Colorado shows that air-sealing homes below 2000 CFM_{50} is not cost-effective. Air leakage must also provide fresh air and remove pollutants when no mechanical ventilation system exists.

Don't intentionally seal homes tighter than 2000 CFM_{50}. While insulation measures may reduce the air leakage rate below 2000 $CFM_{50,}$ the standard allows for some additional air-leakage reduction resulting from the insulation.

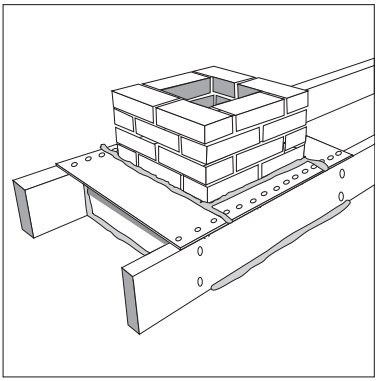
When not to air seal

⌘Perform no air-sealing until the health and safety issues have been corrected:

- Fire hazards jeopardize the occupants' safety.
- The building is already at or below 2000 CFM_{50}.
- Insulation prep will still need to be done if insulation will be added.
- Lack of combustion air is creating spillage of combustion appliances.
- Unvented space heater will be used in the home after weatherization work.
- Moisture has caused structural damage such as rot, mold, or mildew.
- The building is scheduled for demolition or major rehabilitation, and the air-sealing materials would likely be removed.

Bypasses

In Colorado air leaks and bypasses have different definitions. Bypasses are building construction details that allow convection currents to carry heat beyond the thermal boundary. Examples of bypasses are open top plates, chase ways, knee wall junctures, and dropped soffits. Sealing bypasses may not reduce air leakage rates when measured by the blower door, but will reduce heat loss.

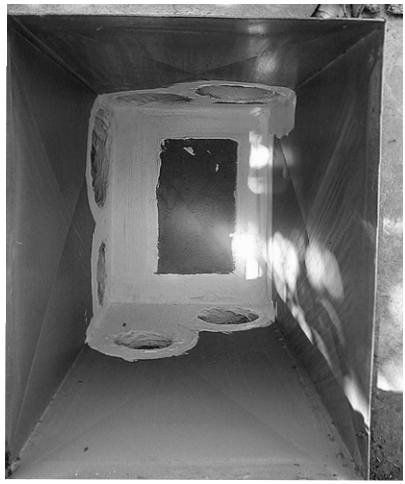


Sealing around chimneys: Use aluminum flashing and high-temperature silicone caulk to seal around chimneys.

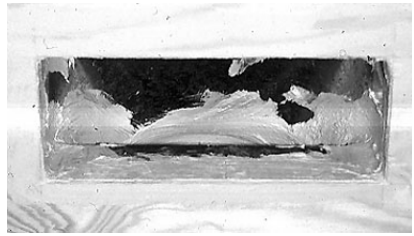
- Blow dense-packed cellulose insulation into the cavity, if it is not a heat source.
- Seal the chimney chase with strips of sheet metal screwed to framing.
- An option is to stuff batts in open wall cavities and to blow then blow cellulose.

6.2 Duct Sealing

- ⌘Assess and repair ductwork as needed to assure that there is good airflow through the system, with minimal leakage of heated air to areas that are not intended to be heated.
- ⌘Assessment will include use of the blower door or other device designed to assist in determining and locating air leakage.
- ⌘Connect and seal all ductwork outside the thermal boundary.
- ⌘Seal return air ductwork in the vicinity of combustion appliances.



Sealing plenums: Sometimes you need to cut an access hole to seal a plenum properly.



Sealing registers to the floor: This practice prevents air leakage from the crawl space or unheated basement.

Duct Sealing Steps

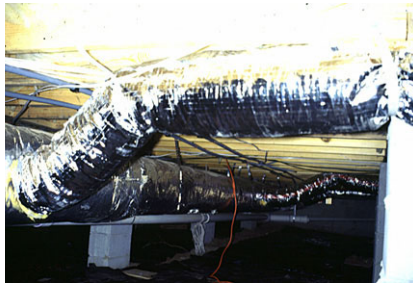
- Determine the location of the ducts. Ducts that are outside of heated space require more attention than ducts located in basements.
- Remove large objects, furniture and clean debris that impede duct airflow.
- While the Blower Door is running up for air leakage work, check the duct supply and return vents for air

leakage. Feel for air movement with your hand, or measure the pressure caused by air leakage.

- With the blower door off, turn on the furnace air handler on and check the house to outside pressure (whole house pressure). Negative pressure means more supply side leaks, positive pressure means that there are more leaks on the return side of the ductwork. The goal is to get the "whole house pressure" to zero. This will minimize heat loss due to pressure embalances.
- Use the furnace air handler or blower door, along with bottled smoke, to locate air movement caused by duct leaks.
- Seal the air leaks, but do not seal seams or connections that do not leak.
- There are usually large return air leaks where duct panning is attached to the bottom of floor joists in a crawl space. Check and seal these areas.
- Reconnect disconnected ducts and secure the connection with sheet metal screws.
- Apply duct mastics that are appropriate for use inside the living space.
- Use mesh and/or screwed sheet metal with mastic whenever the gap is $^1/_4$ inch or more.
- Duct tape, aluminum tape, and butyl aluminum tape are not approved duct sealing materials under E$P.

Duct insulation

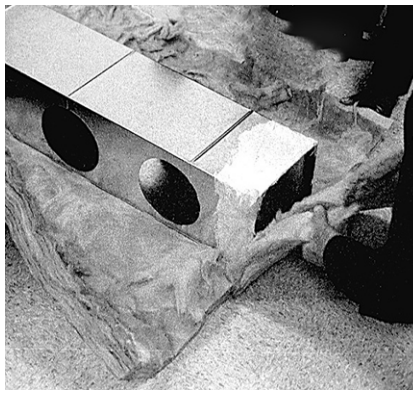
- ⌘Uninsulated ductwork outside the thermal envelope and/or living space must be insulated to R-11.



FSK-faced duct wrap

New ductwork installations

- ⌘New return air ductwork, at a minimum, must either provide a net free area of at least two (2) square inches per 1000 BTUs of input, or the manufacturer's requirements, whichever is greater.
- All new delivery ductwork installations must be installed to maximize airflow whenever possible.



Wrapping new extended plenum: New metal ducts are easier to insulate before they are installed.

- ⌘New ductwork must be rigid metal, whenever feasible.

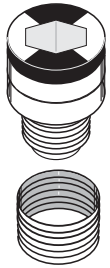
6.3 Attic Insulation

Insulation Safety Procedures

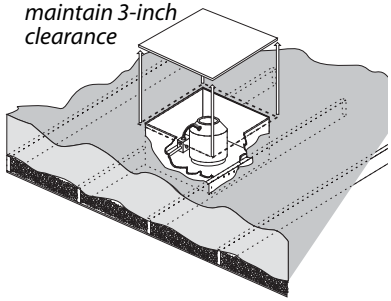
⌘Comply with the following fire and electrical safety procedures before insulating.

- Inspect all attic wiring for unsafe conditions.
- If insulation will cover electrical cable, inspect fuses and breakers to ensure that wiring isn't overloaded.

- Install S-type fuses where appropriate to prevent circuit overloading. Maximum ampacity for 14-gauge wire is 15 amps and for 12-gauge wire is 20 amps. Fuses and breakers should be sized appropriately for the ampacity of the wire they protect.
- Electrical splices must be in closed junction boxes before being covered with insulation.
- If it is not possible to put a splice into junction boxes, isolate the splice with fiberglass insulation. Cut a hole in an unfaced R-38 batt. Lay the batt over the splice to leave the splice exposed within the hole. Make sure that blown-in cellulose is kept away from the splice.



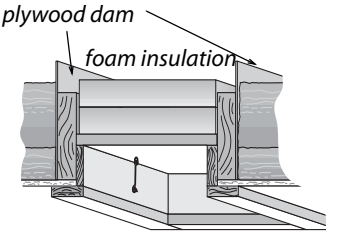
S-type fuse: An S-type fuse prohibits residents from oversizing the fuse and overloading an electrical circuit.



Recessed light fixtures: Covering recessed light fixtures with fire-resistant drywall or sheet-metal enclosures reduces air leakage and allows installers to safely insulate around the box.

- Wear OSHA-approved respirators or dust masks when entering and working in the attic and while blowing insulation or installing batts.
- Install an insulation dam around recessed light fixtures. Metal shielding, boxes made of drywall, or R-38 batt material may be used to isolate the fixture. Leave 1 to 3 inches of air space. If the fixture has IC stamped on it, it may come into contact with the insulation.

- Install junction box covers on open junction boxes; mark the location with a sign or other means.
- Install non-combustible metal dams transformers, furnace and water heater vents and all other heat sources.
- Install metal collars or dams around B-vent chimneys and manufactured all-fuel chimneys.
- Seal any bypasses around chimneys with metal and high-temperature caulk.
- If the knob and tube wiring will remain, dam around the knob and tube wiring with R-30 batts, allowing for free air space around the wiring. Blow cellulose insulation to 1 inch below knob and tube wiring. Use fiberglass batts (R-30 or R-38) laid on its facing to block around the knob-and-tube wiring.
- Shield masonry chimneys used for venting-gas and propane fired appliances by wrapping unfaced fiberglass batt insulation around the chimney before blowing cellulose insulation.



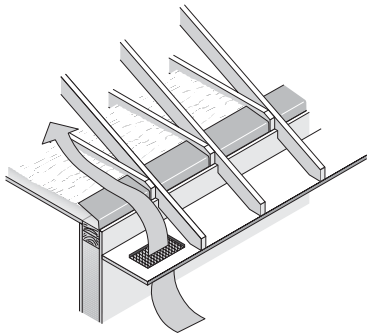
Insulated attic hatch: Foam insulation prevents this area from being a thermal weakness. Building a dam prevents loose-fill insulation from falling down the hatchway.

Preparation for Attic Insulation

⌘Observe the following important preparatory steps before installing attic insulation.

- Install an attic access hatch if none is present. Follow local code requirements. Typical dimensions are 16" x 24", with 32" of overhead clearance.

- Install a rigid (plywood, 1-by-12 lumber, or OSB) dam at the attic access. Batt insulation is permitted for dams in tight spaces.
- Repair roof leaks and other attic-related moisture problems before insulating attic. If attic-related moisture problems cannot be repaired, do not insulate the attic.
- Kitchen and bath fans installed under E$P must be insulated and vented to the outdoors. Use rigid metal piping whenever possible. Consider venting and insulating existing exhaust equipment whenever installing attic insulation.
- Chutes, dams, baffles, or other blocking materials are allowed, but not required. These materials allow narrow air channels between soffit vents and roof vents.
- Attic hatches above heated spaces must be insulated to a minimum of R-19.



Soffit chute or dam: Allows installation of maximum amount of insulation in this cold area. Also prevents wind washing and airway blockage by blown insulation.

Attic ventilation

Install attic vents (roof and gable) only as necessary for access.

Blowing Insulation into an Open Attic

- ⌘Insulate open attics to R-38.
- ⌘Use cellulose insulation in attics. Fiberglass insulation may be used if the ceiling is in poor condition.
- ⌘Determine bag count estimate.
- Blow attic insulation at a higher density helps minimize settling and slows convection currents from moving within the insulation. Try to fill the hose with insulation and minimize the air mixed with the insulation.

Blown-in attic insulation: Blown insulation is more continuous than batts and produces better coverage. Insulation should be blown at a high density to reduce settling.

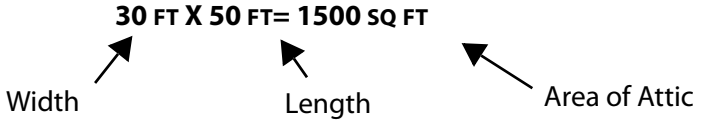
- ⌘Install attic insulation to a uniform depth.
- Ensure good quality coverage by installing paper measuring rulers, especially out at the eave areas.
- Blow one quarter of the attic and count the bags used, if the total bags to be used is 60, 15 bags should have been used at this point. Make adjustments as necessary to achieve good quality coverage and proper bag counts.
- ⌘Keep insulation out of dammed areas or remove blown insulation out of dammed areas as necessary.
- In batt-insulated attics, blow cellulose over poorly installed batts to provide continuous insulation coverage.
- Irregular construction in attics may be overblown with cellulose insulation.

- ⌘Document extra bags of insulation used to overblow irregularities, fill bypasses, or seal air leaks.
- ⌘Install insulation according to manufacturer's specifications.

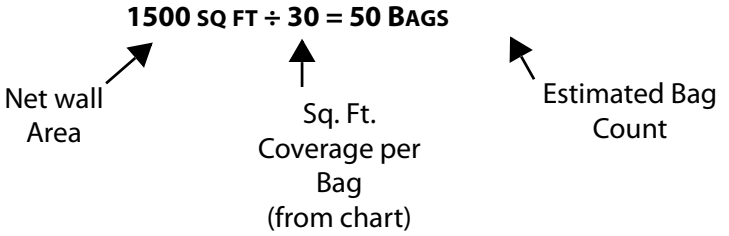
Table 6-2:Insulation Blowing Coverage Chart

Example bag table							
To obtain a minimum density of 1.6 pounds/cubic foot							
	R VALUE AT 78° MEAN TEMP. TO OBTAIN THIS R-VALUE	MINIMUM THICKNESS INSULATION SHOULD NOT BE LESS THAN THIS THICK	MAXIMUM NET COVERAGE MAXIMUM SQ. FT. COVERAGE PER BAG	MAXIMUM NET COVERAGE BAGS PER 1000 SQ. FT	MAXIMUM GROSS COVERAGE BASED ON 2″ x 6″ FRAMING MAXIMUM SQ. FT. COVERAGE PER BAG	MAXIMUM GROSS COVERAGE BASED ON 2″ x 6″ FRAMING BAGS PER 1000 SQ. FT.	MINIMUM WEIGHTS PER SQ. FT. THE WEIGHT PER SQ. FT. OF INSTALLED INSULATION (IN LBS.) SHOULD NOT BE LESS THAN
ATTIC	R-40	10.95	12.9	77.5	13.5	74.2	1.46
	R-38	10.41	13.6	73.5	14.2	70.3	1.38
	R-32	8.76	16.1	62.0	17.1	58.7	1.16
	R-30	8.21	17.2	58.0	18.2	54.8	1.09
	R-27	7.40	18.3	52.2	19.4	51.4	.98
	R-24	6.57	21.5	46.5	23.2	43.0	.87
	R-23	6.30	22.4	44.5	24.2	41.2	.84
	R-19	5.20	27.2	36.7	30.0	33.4	.69
	R-13	3.56	40.2	24.9	46.0	21.7	.47
	R-11	3.01	47.1	21.2	56.0	17.8	.40
SIDEWALLS					2X4 STUDS ON 16″ O.C.		
R-13		3.5			23.6	42.40	.79
R-19		5.5			15.0	66.60	

Calculating Attic Coverage



Step 1: Calculate area of attic:
Multiple length times width of the attic to get the area of attic.

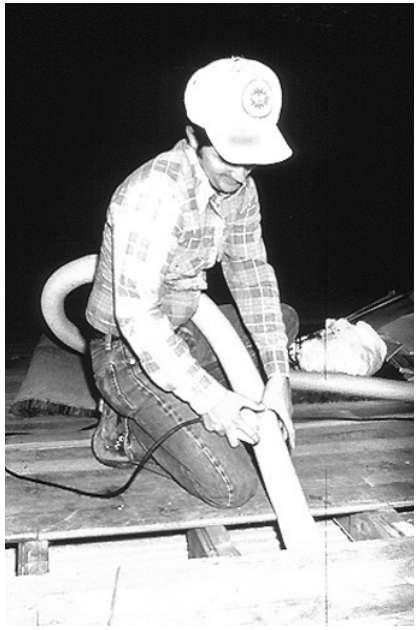


STEP 2: Calculate Bag Count:
Divide area of attic by coverage per bag from the chart on the bag (number double circled in chart) to get your Estimated Bag Count.

Blowing Insulation into a Closed Attic or Roof Cavity

- ⌘Blow as close to R38 as feasible.
- ⌘Insulate so that the thermal boundary is as completely covered as possible.
- Access the cavity or cavities to be insulated by drilling holes at the fascia, soffit, interior ceiling or cut roof vent(s) access holes. Remove the trim to access the cavity, if possible.

- Use rigid pipe or fill tubes as necessary to reach the entire area and fill the cavity.
- Seal access holes with plugs and adhesive, install roof vents or re-install the removed trim.



Tip: If the walls at thermal boundary are open at the top or bottom, these walls should be blown with insulation first. This eliminates removing the siding and or drilling of holes, which saves lots of labor and time. Use a piece of batt insulation to plug the opening while you blow. This will allow you to pack the blown insulation.

Installing batt insulation

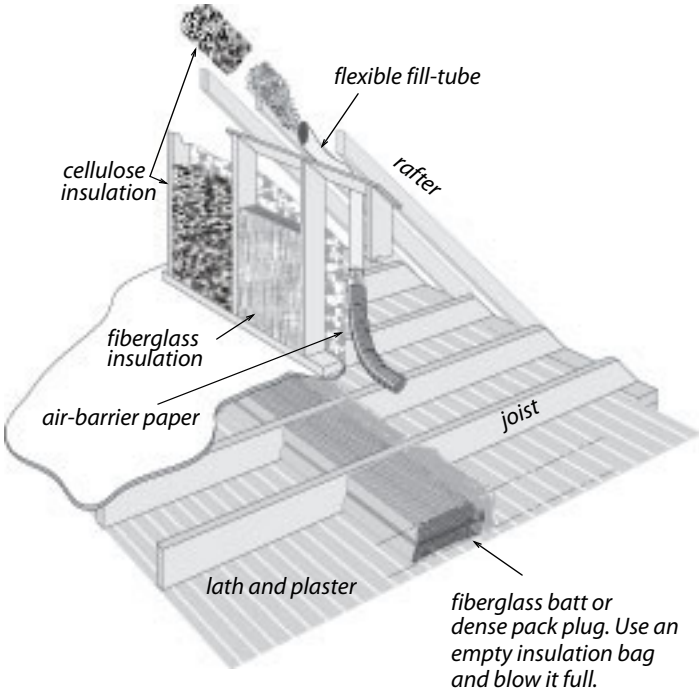
- ⌘If batt insulation must be used in the attic, then it must be installed so as to ensure a tight fit against the ceiling joists.
- ⌘If the insulation has vapor barrier facing, place it toward the heated space.

Finished Knee-wall Attics

The finished attic consists of five separate sections that may require different sealing and insulating methods.

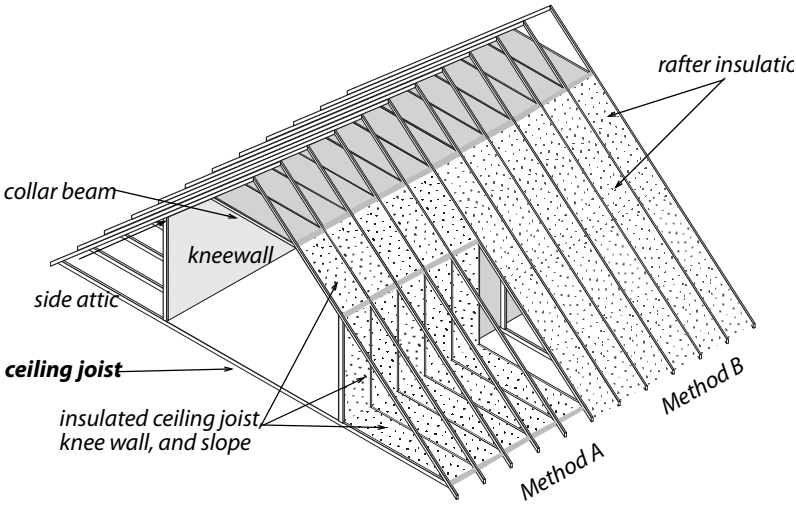
- Exterior walls of finished attic
- Collar-beam attic, above finished attic.

- Roof rafters (sloped roof), where drywall, plaster, or paneling is installed directly to roof rafters
- Knee walls, between finished attic and unconditioned attic space



Finished attic best practices: Air sealing and insulation combine to dramatically reduce heat transmission and air leakage in homes with finished attics.

- Outer ceiling joists, between knee wall and top plate of exterior wall



Finished attic: This illustration depicts two approaches to insulating a finished attic. Either A) insulate the kneewall and side attic floor, or B) insulate the rafters.

Finished attic preparation

- Seal attic bypasses before insulating. Assure adequate structural integrity to support the weight of the insulation.

Create an airtight seal in the joist space under the knee wall; use the following methods:

- Stuff fiberglass batts or other material approximately 12 inches from the end of the joist cavity. Dense pack this area with cellulose.
- Where possible, insulate sloped roof with dense-pack cellulose, using a fill tube from top or bottom. Block one end of the cavity, and dense pack the cavity.

Insulate knee walls with:

- Fiberglass batt insulation.

- Densely packed cellulose or fiberglass; install house wrap to the knee wall and blow through a slit in the house wrap.
- Install insulation at upper collar-beam attic to an R-38.
- Insulate the outer ceiling joints as an open blow if there is no decking. If there is decking (at the outer ceiling), install insulation below decking. If the owner permits, insulate above the decking to achieve an R-38.
- Insulate knee-wall access hatches and collar-beam access hatch with rigid or batt insulation, securely fastened, to match as closely as possible the surrounding insulation R-value.

Tip: Use fiberglass batt insulation as a dam at the collar-beam access if there is insufficient clearance for a rigid dam.

Walk-up Stairway and Door

Establish a continuous insulation and air barrier around or over the top of an attic stairway.

6.4 Wall Insulation

Genereal Requirements

- ⌘Use a fill tube and dense-pack method whenever possible to ensure that wall insulation coverage is complete and the insulation density meets expectations.
- ⌘Plugs and patching must be effective and presentable.
- ⌘Dust Control procedures must be followed whenever painted surfaces will be disturbed, inside and outside.
- ⌘Take the time to find the easiest, least intrusive way to install wall insulation! Look for open top plates in the attic, etc. Don't get stuck using one method.

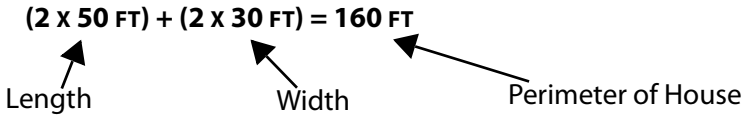
Inspecting and Repairing Walls

- Inspect walls for plumbing and electrical hazards, moisture or structural problems. Do not fill double hung window weight channels and pocket doors with insulation.
- Seal gaps in external window trim and other areas that may admit rain water into the wall.
- Inspect indoor surfaces of exterior walls to assure that they are strong enough to withstand the force of insulation blowing.

Tip: Use temporary braces (1 x 4 or 2 x 4 screwed to the wall) to secure the wall if necessary; remove the braces after the walls are insulated and patch screw holes with spackle.

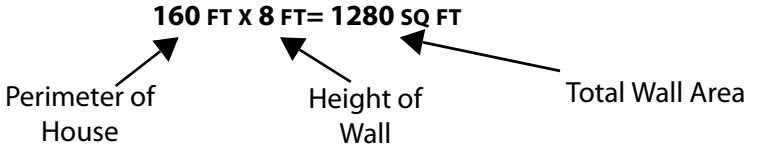
- Inspect for and seal interior openings, from which insulation may escape. Examples: pocket doors, balloon framing, un-backed cabinets, interior soffits, and unfinished closets
- Ensure that exterior wall cavities used as return ducts are not filled with insulation.
- Remove or have client remove items on the exterior wall that could get damaged while blowing the sidewalls.

CALCULATING WALL COVERAGE



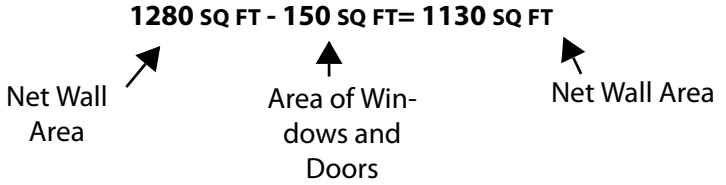
STEP 1: Calculate perimeter of house:

Calculate the perimeter of the house. If the house is a simple rectangle or near a simple rectangle, use the formula above. If the house has numerous unequal sides, simply add the lengths together to find the perimeter.



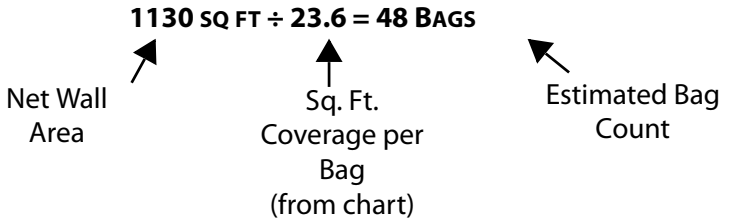
STEP 2: Calculate total wall area:

After calculating the perimeter of the house, multiply it times the wall height. This will give you the total wall area.



STEP 3: Calculate Net Wall Area:

Calculate the sum of the areas of windows and doors. Subtract them from the total wall area to get net wall area.



STEP 4: Calculate Bag Count:

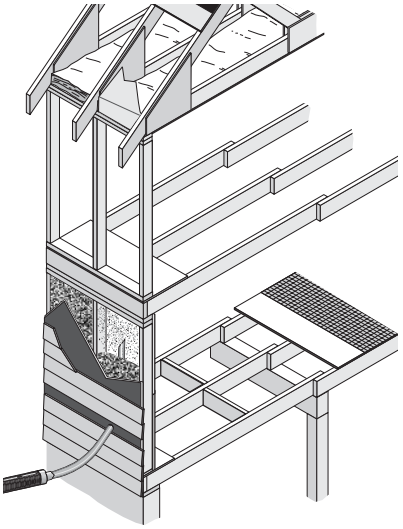
Divide net wall area by coverage per bag from the chart on the bag (number circled

Table 6-3:Insulation blowing coverage chart

Example bag table							
To obtain a minimum density of 1.6 pounds/cubic foot							
	R VALUE AT 78° MEAN TEMP.	MINIMUM THICKNESS	MAXIMUM NET COVERAGE		MAXIMUM GROSS COVERAGE BASED ON 2" x 6" FRAMING		MINIMUM WEIGHTS PER SQ. FT.
	TO OBTAIN THIS R-VALUE	INSULATION SHOULD NOT BE LESS THAN THIS THICK	MAXIMUM SQ. FT. COVERAGE PER BAG	BAGS PER 1000 SQ. FT	MAXIMUM SQ. FT. COVERAGE PER BAG	BAGS PER 1000 SQ. FT.	THE WEIGHT PER SQ. FT. OF INSTALLED INSULATION (IN LBS.) SHOULD NOT BE LESS THAN
ATTIC	R-40	10.95	12.9	77.5	13.5	74.2	1.46
	R-38	10.41	13.6	73.5	14.2	70.3	1.38
	R-32	8.76	16.1	62.0	17.1	58.7	1.16
	R-30	8.21	17.2	58.0	18.2	54.8	1.09
	R-27	7.40	18.3	52.2	19.4	51.4	.98
	R-24	6.57	21.5	46.5	23.2	43.0	.87
	R-23	6.30	22.4	44.5	24.2	41.2	.84
	R-19	5.20	27.2	36.7	30.0	33.4	.69
	R-13	3.56	40.2	24.9	46.0	21.7	.47
	R-11	3.01	47.1	21.2	56.0	17.8	.40
SIDEWALLS					2X4 STUDS ON 16" O.C.		
R-13		3.5			23.6	42.40	.79

Blowing Dense-packed Insulation

- ⌘Ensure that your insulation blowing equipment is producing enough air pressure (95PSI at the end of the tube)to densely pack cellulose.
- Drill 2-to-3-inch diameter holes to access stud cavity. To prevent settling, cellulose insulation must be blown to at least 3.25 pounds per cubic foot density. (This amounts to 9 pounds per full-height cavity or about 0.82 pounds per square foot of wall area for standard 2-by-4 wall.)



Tube-filling walls: This method can be accomplished from inside or outside the home. It is the preferred wall insulation method because it is a reliable way to achieve a uniform coverage and density.

- Blowing cellulose insulation this densely requires using a fill tube that will reach to the far ends of the cavity from the access hole.
- Dense-pack wall insulation is best installed using a blower equipped with separate controls for air and material feed.
- ⌘Mark the fill tube in one-foot intervals to help the person blowing insulation to verify the correct penetration of the tube into the wall.
- Dense pack insulation is achieved by pushing and pulling the fill tube in the cavity as it fills.

6.5 Dealing with Exterior Siding

Dust Control

- ⌘Follow dust-control procedures.*See "Dust Control" on page 44.*
- ⌘Document pre existing paint in the soil.
- ⌘Cover on the ground below and adjacent to the work area with durable protective plastic sheeting(4 or 6ml.).
- ⌘Drill all the holes only in the prepared area.
- ⌘HEPA vacuum clean the wall areas, drill shroud, drill, vacuum and worker clothing and equipment, before leaving the area.
- ⌘Roll up the plastic sheeting carefully, so that no debris or dust can spill. Place the plastic in a garbage bag and tape it shut.

Clean Up and disposal:

- ⌘Empty debris from HEPA vacuums off-site. Follow the manufacturer's instructions for emptying and cleaning.
- ⌘Dispose of bagged paint dust and debris off-site.

Siding Removal

- Where possible, carefully remove siding and drill through sheathing. This avoids the potential lead-paint hazard of drilling the siding. It also makes it easier to insert flexible fill tubes since the holes pass through one less layer of material.
- If the siding cannot be removed, consider drilling the walls from inside the home.

- ⌘Probe all wall cavities through holes, as you drill them, to identify fire blocking, diagonal bracing, and other obstacles.
- ⌘After probing, drill whatever additional holes are necessary to ensure complete coverage.

The following types of siding are removable for installing wall insulation from the exterior by the dense-pack method:

- Wood or masonite lap siding,
- Shingled siding,
- Vinyl or metal, and
- Transite.

How to Remove Exterior Siding

Wood or masonite lap siding

- Explain the sidewall method to the client before beginning the work.
- ⌘Use a utility knife to scribe the paint on the pieces of siding that will be removed.
- Remove a row of siding below windows around the perimeter of the house.
- To remove siding, pull the nails with a flat bar (wonder bar) and hammer or use a pin punch to drive the nails through the siding to be removed and the pieces of siding above the siding to be removed.
- Set siding out of the way to avoid damage.
- Drill through sheathing (lumber or plywood) to access the cavity. Drill or knock a hole into the Celotex board. If no sheathing exists, use batt material to block the cavity as it is blown.

- Insert a tape measure or wire into the drilled hole and push to the stud cavity to locate the next stud.
- Insert fill tube into the cavity and dense pack the wall cavity.
- Use a small nozzle and matching hole to insulate smaller wall cavities. Follow drill-and-blow hole-sealing procedures.
- Remove additional siding as needed if there is blocking in the wall cavity.
- Re-install siding, use longer galvanized nails if necessary to secure the siding.
- Re-hang wall hangings taken down.

Wood-shingle siding

- Cut the wood shingle with a utility knife at the bottom edge of the upper row of shingles where insulation is to be installed.

- Remove shingle and drill through the now exposed shingle and sheathing to access the cavity.
- Insert a tape measure or wire into the drilled hole to locate the stud.

- Insert fill tube into the cavity and dense pack the wall cavity.
- Install wood plugs with adhesive at the hole.
- Re-install the removed portion of shingle with adhesive and galvanized nails as necessary.
- Drill holes through the shingles to be replaced to prevent the siding from splitting when re-nailed.
- Touch up any areas in need with paint if shingles are painted.

Wood shingles on a Celotex backing

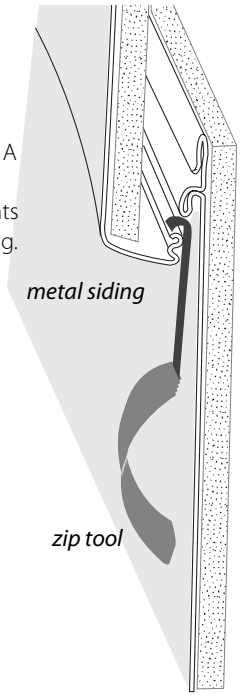
- Shingles on a Celotex backing will have to be removed in sections (usually 2 to 3 feet) This type of siding will be removed like lap siding, only in shorter sections.

- Remove the siding above the doors and windows in the same manner.
- Insert fill tube into the cavity and dense pack the wall cavity.
- Re-install the removed sections of shingles with adhesive and galvanized nails as necessary.
- Touch up any areas in need with paint if shingles are painted.

Vinyl or metal siding

Vinyl and metal siding is usually installed over the original siding with $^1/_4$-inch to 1-inch thick board insulation.

- Unzip vinyl siding (at the piece of siding above the piece to be removed) with a zip tool.
- Remove roofing nails from the flange.
- Unzip siding piece to be removed.
- Cut out board insulation to gain access to original siding.
- Drill or remove original siding as feasible to access the cavity.



Removing metal siding: A zip tool separates joints in metal siding.

Note: Once you have removed the vinyl or metal siding, don't try to remove the original wood siding underneath it. Just drill through the wood.

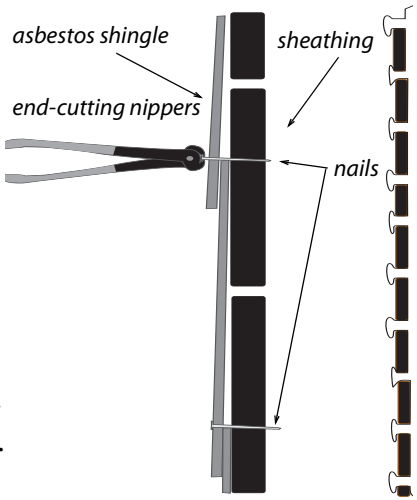
- Insert fill tube into the cavities and dense pack the wall cavities.
- Re-install board insulation with adhesive or nails.
- Re-install the vinyl siding.

Metal siding is much more difficult to remove than vinyl siding. It is difficult to re-install the siding without doing some kind of damage. Use the same method as vinyl siding. The top row of siding can sometimes be removed much easier than a row of siding in the middle of the wall section.

Transite (asbestos) siding

Use caution removing nails. This siding will crack and break if you pry against it.

- End-cutting nippers are needed to remove this type of siding.
- Drill sheathing and dense pack the cavities.
- Replace shingles using aluminum or galvanized nails.



Exterior Wall Insulation: Drill and Blow

⌘Follow "Dust Control" procedures as described earlier in this chapter.

Tube-filling walls is the only reliable wall insulation method because it is the only way to consistently achieve a uniform coverage and density. See the "Blowing Dense Pack Insulation" section in this chapter.

- ⌘Empty wall cavities above windows and doors, and the area below windows must be insulated, where possible. Use a directional nozzle for this.
- ⌘When drilling through paint, use a drill shroud and HEPA vacuum. Once the paint has been removed, a shroud and HEPA vacuum are not necessary. Use of two separate drill set ups to help speed the work.
- Drill holes at a height that is comfortable. Drilling to high or to low can cause injuries.
- Drill holes at a slight angle. This will help when inserting the fill tube into the wall cavity.
- When insulating balloon-framed walls, try to blow an insulation plug into each floor cavity to insulate the perimeter between the two floors. This also seals the floor cavity so it does not become a conduit for air migration. If the process is requiring too much insulation, try placing a plastic bag over the end of the fill tube and blowing the insulation into the plastic bag. The bag will limit the amount of insulation it takes to plug this area.
- Probe wall cavities to determine location of obstacles and nature of cavities around window and door areas.

Note: Blowing large areas with a nozzle is not recommended. When using a nozzle of 1 1/2 inches or less in diameter, three or more holes per stud cavity are required.

Plugs and Patching

- ⌘Plugs that are compatible with the siding or wall type must be used to cover the exposed surface that has been drilled.
- ⌘Plugs must be seated tightly and the finished patch must be flush with the finished wall or siding.

- ⌘Plugs and patching must be presentable and ready for a final coat of paint. Silicon may not remain on the surface of the plug.
- ⌘Plugs must be primed and glued in place when exposed to weather. Use exterior grade materials.
- The patches may be painted to match the existing color of the home.

Interior drill and blow

When installing wall insulation from the interior, practice lead-safe weatherization techniques.

- ⌘Cover furniture with plastic.
- ⌘Tent off the area where work is to be performed by taping a continuous sheet of plastic from floor to ceiling.
- ⌘Deactivate the furnace and swamp cooler air handler so that it cannot be energized while disturbing painted surfaces. Close all windows.

- ⌘Drill through paint using a drill with shroud and HEPA vacuum.
- Holes can be completed with ordinary equipment. Foam inserts placed in the hole saw will automatically eject the hole core into the wall cavity.
- Use a tape measure or wire to determine where to drill into the next cavity.
- Insert a fill tube and dense-pack the cavity.
- Slightly recess wood plugs into the holes.
- ⌘Use spackle or drywall comound in conjunction with mesh tape to seal the holes.

See "Dust Control" on page 44.

Interior Brick Veneer

If possible, consider drilling into the wall cavity from below. It will be easier and much faster.

- Be sure that the exterior sits to the interior side of the foundation wall.
- From the crawlspace or basement, drill 1" or 2" holes through the sub floor and sole plate, angled toward the exterior of the wall cavity.
- Insert a small diameter fill tube into the wall cavity. Make sure that it gets to the top of the wall. Use a sponge or some batt material to prevent back pressure from blowing insulation out of the hole.
- Pack the cavity with insulation.
- Insulate above doors and windows from the exterior, if necessary.

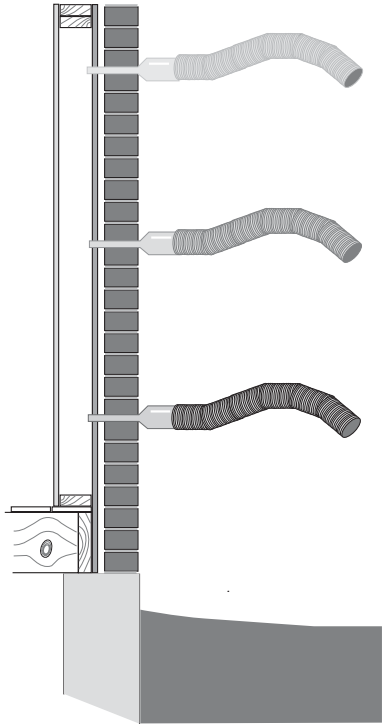
Exterior Brick Veneer (Last Resort)

The right hammer drill and 5/8-inch masonry bit are required for a brick veneer wall.

- ⌘A minimum of three (3) holes per full height stud cavity is required for this method.
- Drill a hole into a stud wall cavity at the corner of a mortar joint in the brick veneer at 4 feet from the top of the wall.

Note: There will be a finger space between the brick and the sheathing, usually $^{1}/_{2}$ to 1 inch.

- Drill a hole in the same stud cavity within one foot from the top of the cavity.
- Drill a hole in the same stud cavity two feet up from the bottom.
- Drill a third hole halfway between the top and the bottom hole.
- Turn material feed way down.



- Obtain a brick nozzle available at your insulation supply house or make one out of copper tubing.
- Insert brick nozzle into the bottom hole and fill this portion of the wall cavity.
- Fill the bottom section of the wall cavity.
- Insert brick nozzle into the middle cavity and fill this portion of the wall cavity.
- Insert brick nozzle into the top cavity and fill this portion of the wall cavity.
- Repeat this procedure until all wall cavities are insulated.
- Fill holes with pre-mix mortar compound or mix mortar compound on site.
- Use a jointer tool to smooth out the mortar in the joint.

6.6 Floor and Foundation Insulation

Ground Moisture Barriers

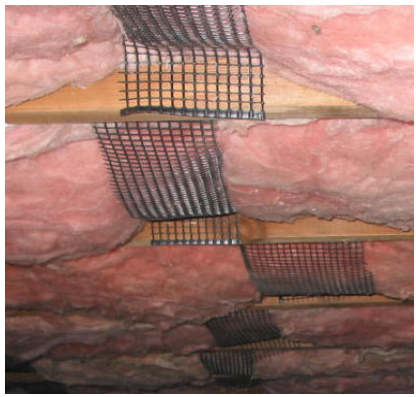
- ⌘If there is evidence of moisture in a crawl space install a ground moisture barrier that covers the all exposed dirt and the foundation wall footings.
- Evidence of moisture percolation is any ground material that is not completely loose and dry. If unsure, place a 3-foot by 3-foot piece of plastic on the ground for at least one night. If there is condensation on the underside of the plastic, install a ground moisture barrier.
- ⌘Use 6-mil plastic and overlap the edges 12 inches.
- ⌘Secure the ground moisture barrier with rocks, earth or use U shaped tent stakes to secure the seams.

Foundation Wall Vapor Barrier

- ⌘If there is evidence of bulk water leakage through the foundation wall, install 6-mil moisture barrier that covers the entire foundation wall.
- Fold the plastic two or three times (a couple of inches) and secure it to the sill plate or cripple wall sill plate (just above the concrete) with staples.
- Overlap the seams at least 12 inches.
- ⌘Run the bottom of the foundation vapor barrier out at least 12 inches from the foundation wall.
- Place the ground moisture barrier over the bottom of the foundation wall vapor barrier.

Floor Insulation

- ⌘Seal penetrations at the floor before installing insulation. (Align the thermal boundary)
- Install R-19 batt insulation between floor joists with the vapor barrier to the heated space, or install unfaced batts.
- Cut the batt insulation to fit tightly into the cavity, through cross bracing, and other obstructions.



Nylon mesh: This floor insulation is held up next to the bottom of the floor by nylon mesh, stapled in place.

- Secure the insulation in the floor joists. Mesh, or other material may be used, so long as it is securely fastened.

- ⌘Wire (Tiger Claws, “lightnig rods”) fasteners may not be used.
- The batt has to be installed so that there is no air space between the floor and the batt.
- Friction fitting or stapling through insulation is not allowed as a method for securing the material.

Crawl Space Foundation Insulation

General Requirements

- ⌘A minimum insulation blanket of of R-11 must be installed, if cost-effective.
- ⌘The insulation must be installed so that it is durable and effective.
- ⌘An FSK25 facing placed to the interior is required to protect the insulation, and to allow for a strong attach-mnet surface.

Procedures

- Use a 4 foot wide, FSK25 faced, R-11 insulation blanket.
- Roll out insulation blanket along the foundation wall with the facing to the ground.
- Lift approximately 5 feet of the insulation blanket up to the sill plate.
- Staple the tab of the insulation blanket to the plate.

- Cut insulation pieces to fit into box sills and insulate.
- Cover all the exterior surfaces of the foundation wall. If codes allow, install the insulation over foundation vents.
- Keep the blanket flat against the foundation wall.
- Install aluminized bubble pack material at the access. Staple two pieces of the material to the sill and overlap it in the middle. This will allow the client to enter and exit the crawl space without having to remove the blanket insulation.

- Insulate between any water pipes or furnace delivery boots and the exterior rim joists so as not to isolate water pipes and keep the residual heat in the crawl space.
- Insulate water pipes separately as necessary to prevent freezing.
- If the heating system is located in crawl space, precautions must be taken to assure that adequate outside combustion air is available.
- Encapsulated Perimeter Insulation may be used in place of installing vapor barrier against the foundation wall. (see:Mobile Home Perimeter Insulation)

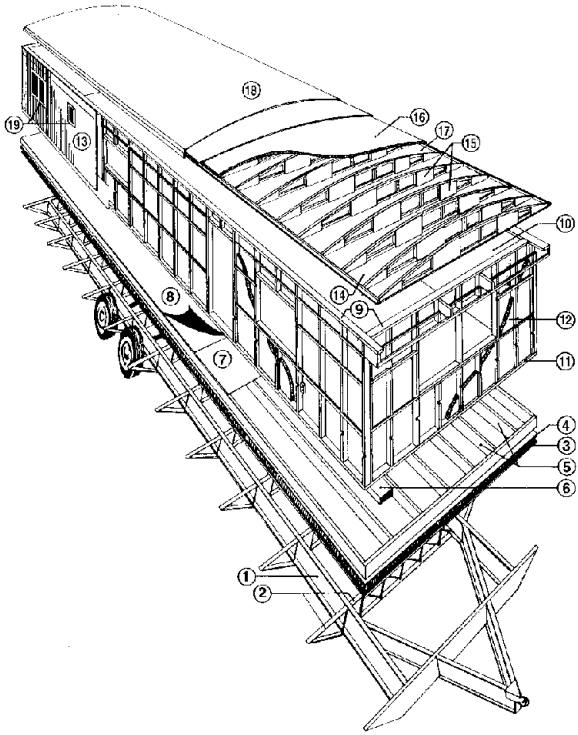
Rim Joist Insulation in Basements

- ⌘Install insulation at the rim joist areas in all accessible areas. Fiberglass insulation must not to be left exposed in the living area.
- Seal air leaks to the outside with caulk.
- Cut pieces of batt material to fit the cavity sizes; cut the pieces larger than the cavity to allow for stapling.

- Insert insulation into the cavity and secure with staples to the floor, floor joists and sill plate as necessary.
- Remove panels along the exterior wall. If a suspended ceiling is present, seal leaks at the rim joist and install insulation. Re-install the panels when insulation work is completed.

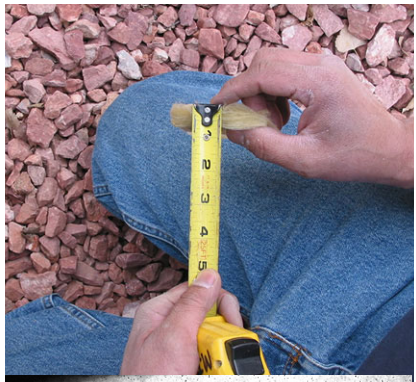
CHAPTER 7 MOBILE HOME PROCEDURES

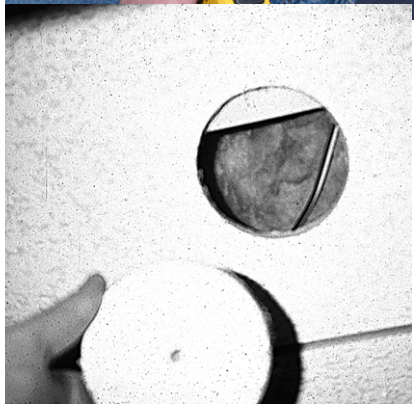
Mobile homes typically use more energy per square foot. Their consistent construction makes them more straightforward to weatherize. Insulation upgrades save the most energy in mobile homes, though sealing shell and duct air leaks presents good opportunities, too. Mobile home heating retrofit and replacement are often cost-effective when a client's energy usage is high.



Typical Components of a Mobile Home: 1–Steel chassis. 2–Steel outriggers and cross members. 3–Underbelly. 4–Fiberglass insulation. 5–Floor joists. 6–Heating/air conditioning duct. 7–Decking. 8–Floor covering. 9–Top plate. 10–Interior paneling. 11–Bottom plate. 12–Fiberglass insulation. 13–Metal siding. 14–Ceiling board. 15–Bowstring trusses. 16–Fiberglass insulation. 17–Vapor barrier. 18–Galvanized steel one-piece roof. 19–Metal windows.

7.1 Mobile Home Auditing





- Introduce yourself to the client and associate yourself with your agency.
- Explain to the client that you will need access to all areas of the home including bedrooms, bathrooms, and closets.
- Ask the client if there are problems with the furnace, water heater or any problems in general with the mobile home.
- Advise the client that inspection holes will need to be made in inconspicuous locations throughout the mobile for auditing and inspection purposes.
- Explain the general procedure of the audit and the weatherization process including the blower door test, health and safety tests, insulation levels, etc.
- Keep the client informed throughout the entire weatherization process.

See "Audit Procedures" on page 27.

Health and Safety

- ⌘Check the furnace for cracks in the heat exchanger, gas leaks, carbon monoxide, flex connector, and venting.
- ⌘Check the water heater for carbon monoxide, spillage, venting, gas leaks, and adequate combustion air.
- Open-combustion furnaces and water heaters located in the living space and experiencing safety problems should be replaced. New furnaces and water heaters should be sealed-combustion units, labeled and approved for mobile or manufactured homes.
- ⌘Check gas range and dryer gas line flex connector.
- ⌘Check dryer (gas or electric). It must be vented to the outside.
- ⌘Check for mold and mildew especially at the bath and kitchen areas.
- ⌘Assess the structural conditions of the mobile home for potentially dangerous situations.
- ⌘Repair of moisture problems is required if they degrade any weatherization measures to be installed (plumbing leaks, roof leaks).
- ⌘Repair any health and safety issues as necessary.

See "Health, Safety, and Durability" on page 39.

Assessing Space for Insulation

- Using a 4" hole saw and plastic hole cover allows the auditor to get a good look in ceiling and wall cavities. Be sure to locate the hole in an inconspicuous place.
- Measure the ceiling cavity at the center and the edge of the mobile home.

- Measure the wall cavity and batt sizes within the wall.
- Ask the client if they have any electrical problems. For example: lights flickering, non-functioning outlets, etc.
- Check the electrical breaker/fuse box and wiring for adequacy.
- ⌘#12 aluminum or #14 copper must be protected with 15 amp fuses or breakers.
- ⌘#10 aluminum or #12 copper must be protected with 20 amp fuses or breakers.
- ⌘Also check for reversed polarity, correct voltage, and proper grounding, using a circuit analyzer.
- ⌘Check for voltage drops of more than 10%. Corrective action must be taken where voltage drops are more than 10% and insulation will be added over the electrical wiring.

- ⌘Document electrical safety problems and have them repaired by an qualified technician. The repair with the energy-conservation measure must be cost-effective.

See "Electrical Safety" on page 46.

- Measure the depth of the wing and center belly cavities. Also measure the original batt size at the more than one location within the belly.
- Assess the belly condition, plumbing leaks, exposed ductwork, and necessary repairs.
- Check the general condition of the ceiling, walls, floors, doors, windows, and ductwork from inside the home.
- Check supply ducts and registers for air leaks. Check for a return air system in the belly and or ceiling.

Necessary Repairs

Do cost-effective repairs to the ceiling, sidewall and belly as necessary. Much of this type of work is related to the insulation preparation and usually needed before adding the insulation. Some examples of necessary repairs are:

- Roof leaks and repairs,
- Moisture and drainage repairs,
- Ceiling panel repair and or replacement,
- Belly repairs,
- Plumbing repairs,
- Ductwork repairs, and
- Ground moisture barrier.

See "Health, Safety, and Durability" on page 39.

See "Doing the Work" on page 31.

7.2 Mobile-Home Air Sealing

The locations and relative importance of air-leakage sites was a mystery before blower doors. Some mobile homes are fairly airtight and some are incredibly leaky. ⌘A blower door must be used to guide air-sealing work.

See "Blower-door Testing Procedures" on page 105.

Air-leakage Locations

The following locations have been identified by technicians using blower doors as the most serious air-leakage sites. Window and door air leakage is more of a comfort problem than a serious energy problem.

- Plumbing penetrations in floors, walls, and ceilings For example: behind washers and dryers. Water-heater closets with exterior doors are particularly serious air-leakage problems, having large openings into the bathroom and other areas.
- Torn or missing underbelly, exposing air leaks in the floor to outdoors.
- Large gaps around furnace and water heater chimneys.
- Severely deteriorated floors in water heater compartments.
- Gaps around the electrical service panel box, light fixtures, and fans.
- Joints between the halves of doublewide mobile homes and between the main dwelling and additions.

Table 7-1:Air-Leak Locations and Typical CFM50 Reductions

Leak to be Sealed	Possible Reduction
Sealing floor as return-air plenum	300–900

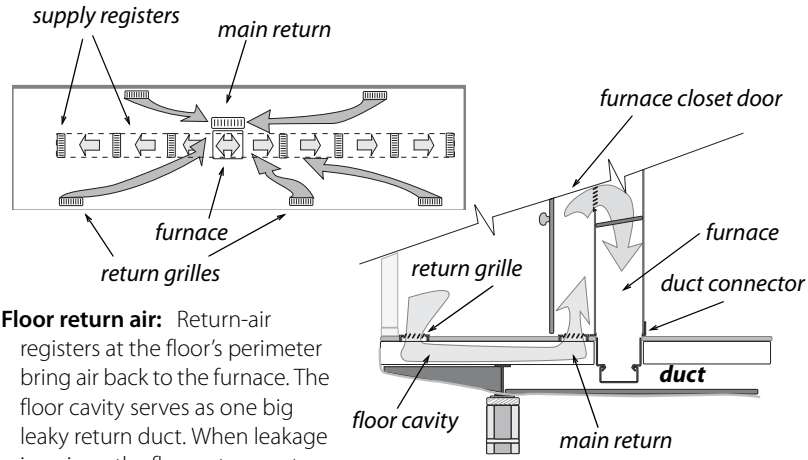
Table 7-1:Air-Leak Locations and Typical CFM50 Reductions

Leak to be Sealed	Possible Reduction
Sealing leaky water-heater closet	200–600
Sealing leaky supply ducts	100–500
Patching large air leaks in the floor, walls and ceiling	200–900
Patching large air leaks in the floor, walls and ceiling	200–900
Caulking and weatherstripping	50–150
Installing tight interior storm windows	100–250

Mobile Home Duct Sealing

General Requirements

- ⌘Ducts must be assessed for air leakage using a blower door or other duct leak assessment tool.
- ⌘Duct leaks must be sealed effectively.
- ⌘Disconnected, damaged or poorly joined crossover duct must be sealed, insulated and raised off the ground, if possible.
- ⌘Floor and ceiling cavities used as return-air plenums must be eliminated in favor of return-air through the hall or a large grille in the furnace-closet door, if feasible.
- ⌘The furnace to main duct boot must always be checked and sealed if leaking.
- The main duct may need to be cut open from underneath to access and seal these leaks between the furnace, duct connector, and main duct. For furnaces with empty



Floor return air: Return-air registers at the floor's perimeter bring air back to the furnace. The floor cavity serves as one big leaky return duct. When leakage is serious, the floor return system should be eliminated.

A-coil compartments, you can simply remove the access panel to access the duct connector.

- ⌘Seal joints between the main duct and the short riser duct sections.
- ⌘Seal joints between register boots and floor. Use caulk. Do not replace the register until the sealant is dry.
- Check for leaks at the end of the duct trunk. Use a sealed plastic bag that has been tightly filled with insulation, or other effective method, to block off the end of the trunk. Ramping with sheet metal does not improve airflow, and is therefor unnecessary.

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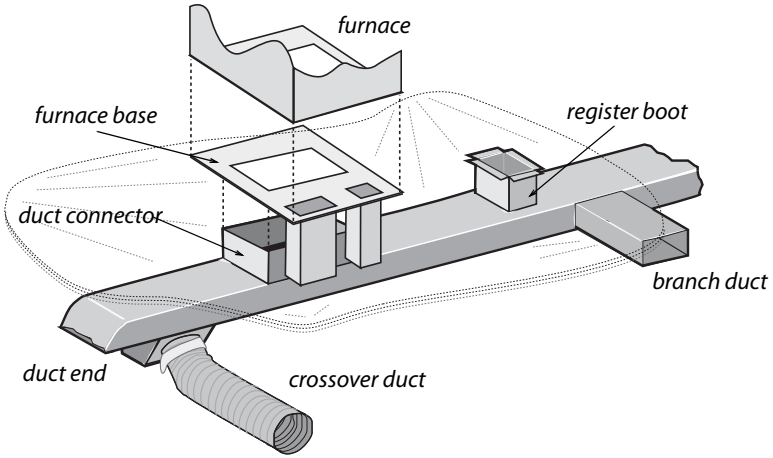


Mobile home ducts: Mobile home ducts leak at their ends and joints—especially at the joints beneath the furnace. The furnace base attaches the furnace to the duct connector. Leaks occur where the duct connector meets the main duct and where it meets the furnace. Branch ducts are rare, but easy to find, because their supply register isn't in line with the others. Crossover ducts are found only in double-wide and triple-wide homes.)

See "Duct Sealing Steps" on page 114.

- ⌘Vacuum and clean ductwork as necessary to remove blockages.
- ⌘Seal boot riser/trunk connection leaks with mastic and mesh tape.
- ⌘Butyl and foil tape is not allowed as a duct sealant.
- ⌘Seal the ductwork with mastic and mesh tape as necessary to seal leaks.
- ⌘Allow the mastic to dry before re-installing the registers.
- ⌘Access furnace boot riser and seal with mastic and mesh. This connection is located just below the furnace. It is the most important air leak to seal in a mobile.

- Install new registers if necessary and fasten them to the floor.

Return air system

- ⌘If the mobile home has a return air system in the belly or ceiling, seal the return air registers permanently, reroute the return through the mobile home and install grilles at the furnace door as necessary to provide adequate return air.

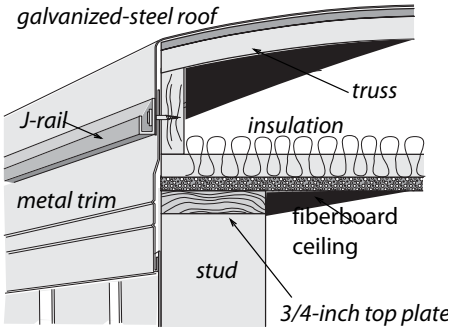
7.3 Mobile Home Insulation

- ⌘Address all significant moisture problems before insulating.
- Fiberglass is the preferred material for insulating mobile homes. Most mobile homes do not have the structural strength to carry the extra weight of cellulose insulation.
- ⌘Insulation must be installed in such a manner that ensures complete coverage over heated areas except those receiving a Agency waiver.
- ⌘Inspect your work to ensure complete coverage.
- Perimeter insulation is preferred over belly insulation due to the high cost and the relatively low savings that have been found in energy evaluation studies for doing belly insulation work.
- ⌘Self inspect insulation coverage while the equipment is set up; check the areas where obtaining complete coverage is difficult.

Blowing Mobile Home Roof Cavities

General Requirements

- ⌘Blow in loose-fill fiberglass.
- ⌘Do not install insulation at a high density.
- ⌘Install insulation so that the coverage is as complete as possible.
- ⌘Seal the roof for water leaks when done insulating.
- ⌘Follow preparation procedures.



Bowstring roof details: Hundreds of thousands of older mobile homes were constructed with these general construction details.

Preparing to blow a mobile home roof

- Inspect the ceiling, and seal all penetrations.
- Reinforce weak areas in the ceiling. For example, add rosettes, washers, or wood lathe with the client's approval.
- Take steps to maintain safe clearances around heat sources. For example: chimneys, fans, light fixtures.
- Assemble patching materials such as metal patches, roof cement, sheet-metal screws, putty tape, and roof coating.

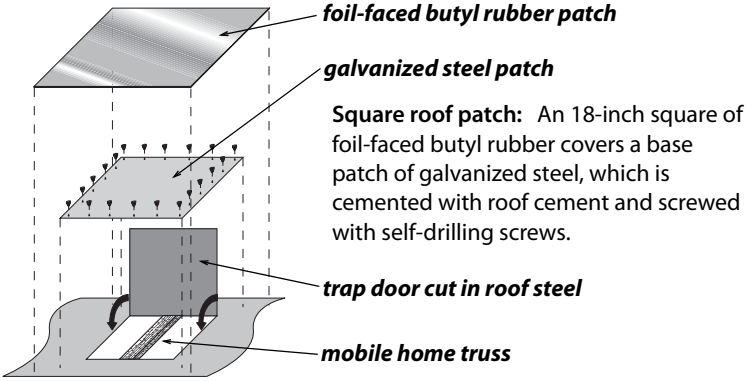
Option #1 Blowing through a large square hole

Roof-top insulation: Blowing fiberglass insulation through the roof top is effective at achieving good coverage and density on almost any metal roof.

This method works well when there are two batts in the ceiling cavity, one on the roof and one on the ceiling because a rigid fill pipe can be used to ensure good coverage at the edges. This procedure involves cutting large square holes. Each square hole provides access to two truss cavities. If the roof contains a strongback running the length of the roof, the holes should be centered over the strongback, which is usually near the center of the roof's width. A strongback is a 1-by-4 or a 1-by-6, installed at a right angle to the trusses near their center point, to add strength to the roof structure. This approach fills the critical edge area with insulation, and the patches are easy to install if you have the right materials. It is important to complete the work during good weather since the roof will be vulnerable to rain or snow during the job.

- Cut 8-inch square holes at the roof's apex on top of every second truss. Each square hole permits access to two truss cavities.
- Use a 2-inch or $2^{1}/_{2}$-inch diameter fill-tube or rigid pipe. Insert the fill-tube and push it out toward the edge of the cavity.
- Blow fiberglass insulation into each cavity.
- Stuff the area under each square hole with a piece of unfaced fiberglass batt so that the finished roof patch will stand a little higher than the surrounding roof.
- Patch the hole with a 12-inch-square piece of stiff 26 gauge galvanized steel, sealed with roof cement and screwed into the existing metal roof.
- Cover the first patch with a second patch,

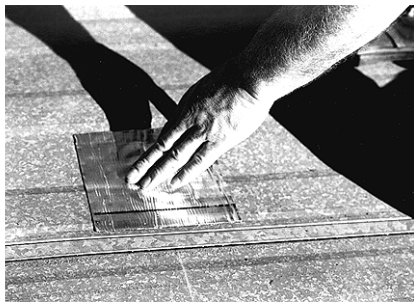
consisting of an 18-inch-square piece of foil-faced butyl rubber.



Square roof patch: An 18-inch square of foil-faced butyl rubber covers a base patch of galvanized steel, which is cemented with roof cement and screwed with self-drilling screws.

Option #2 Drill and blow through the roof

- Drill one or two $2^1/_2$-inch holes into each cavity. Center the holes between the trusses.
- Set the machine material and air according to the size of fill tube being used and density desired.
- Insert the fill tube into the hole. If the insulation batt is on the roof, position the tip of the fill tube pointed toward the ceiling surface. If the insulation batt is on the ceiling, position the fill tube pointed to the roof surface.
- Push the fill tube to the edge of the mobile roof/ceiling.
- Tip: The fill tube should be marked at 1-foot increments. If the edge is 7 feet from the hole, the fill tube should be at the 7-foot mark; if it is not pull the fill tube and insert the fill tube again. If unable to get the fill



tube to the edge, drill another hole on opposite side of the obstacle and fill the remainder of the cavity.

- Pull the fill tube 6 to 12 inches from the edge and begin to fill the cavity.
- Pull the fill tube back as the material begins to slow down or stops until this side of the cavity is filled.
- Fill the other side of the cavity in the same manner.
- Self inspect the insulation coverage by drilling a $2^1/_2$-inch hole within 2 feet of the edge. Check the insulation coverage and feel the density. Make adjustments as necessary. Additional holes may need to be drilled to ensure good coverage.
- Check the bag count estimate when one quarter of the roof has been completed. Divide the total bag count by 4; for example if the estimate is 12 bags, divide 12 by 4, which equals 3. Three bags should have been installed at this point.

Option #3 Blowing a mobile roof from the gable end

This method requires scaffolding, muffler pipe and usually two installers.

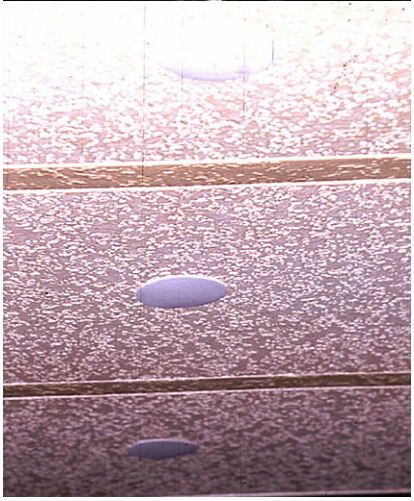
Roof cavity packed with fiberglass

- Remove siding at the gable or cut in access holes.
- Insert muffler pipe into the gable end; add sections of pipe and connect with duct tape.
- Push the connected pipe toward the interior of the mobile home.
- It is usually necessary to insert the tube into both the edges and into the center to get complete coverage.

- Putting a 90° elbow at the end of the pipe and flipping the elbow from one side to the other allows you to get better coverage.
- Pull the muffler pipe out as the cavity fills; it will be necessary to have the other installer help stabilize the pipe as the length of the pipe increases outside of the cavity.
- Re-install the siding at the gable ends or install vents over the access holes that were cut into the gable end siding.
- Repeat the process for the other half of the mobile home ceiling.

Option #4 Interior drill and blow ($2^1/_2$-inch holes)

This procedure requires the drilling of $2^1/_2$-inch holes and blowing insulation into the roof cavity through a fill tube from the interior.



- Drill $2^1/_2$-inch holes down the center of the ceiling. If a strongback exists it may be necessary to drill holes 12 to 16 inches from either side of center.
- Insert a flexible fill tube into the cavity and push it as far as possible toward the edge of the roof.
- Fill the cavity with fiberglass insulation.
- Drill additional holes as necessary to get around blocking or obstacles.
- Seal the holes with plastic plugs.
- Care must be taken not to damage the holes so that the plastic plugs will fit properly. An option is to use wood plugs and drywall tape and mud to secure the wood plugs in the ceiling.

Option #5 Through roof vents in a pitched roof

- Install a roof vent hole, 6 feet in from the gable wall and 18-24 inches from the peak; insulation can be added 6 feet in each direction to the eaves.
- Insert a 2-inch fill tube into the cavity.
- Pull the fill tube back as the cavity fills.
- Change the direction of the fill tube and insulate all sides of the access hole; insulate around the access hole as you finish this area.
- Cut in another roof vent access hole 12 feet on center from the vent installed 6 feet from the gable wall.
- Insulate another 12 feet of the mobile through this access hole using the same method. Repeat this procedure until the entire roof cavity is insulated.
- Install roof vents over access holes.
- Note: Sometimes with double wide mobile homes there is adequate clearance to insulate the ceiling cavity as an open blow. Access to the ceiling cavity can be gained through the gable end by removing the siding panel(s). The use of 1-by-12 lumber is necessary to distribute the weight of the installer and to make moving around easier due to webbed trusses.

Option #6 Blowing ceiling from the edge

This procedure requires scaffold to be performed safely and efficiently. Mobile home metal roofs are usually fastened only at the edge, where the roof joins the wall.

Roof-edge blowing: Use a rigid fill tube to blow insulation through the roof edge. This avoids making holes in the roof itself, though this process requires much care in refastening the roof edge.

- Remove the screws from the metal j-rail at the roof edge. Also remove staples or other fasteners, and scrape off putty tape.
- Pry the metal roof up.
- Insert a 2-inch diameter 15-foot-long rigid fill pipe. Use short pieces of 2-by-4 lumber to hold the cavity open.

- Blow insulation through the fill-tube into the cavity.
- Blow the edge area light or stuff the last foot or two with unfaced fiberglass batts.
- Note: It is critical not to overfill this area with insulation near the edge; it is difficult to put the roof back down if the edge is overfilled.
- Fasten the roof edge back to the wall using galvanized roofing nails, wide-crown staples, metal j-rail, new putty tape or caulk, and larger screws.

Mobile Home Wall Insulation

- Check outlets and switches (electrical) at the exterior walls and note the results in the client file. Make sure client is aware of any problems before insulating the walls.

- Remove pictures/wall hangings from the interior walls.
- Set machine to lower settings (this is not a dense pack).

- Remove bottom row of screws and middle row of screws as necessary. Use zip screws ($^3/_4$-inch hex head) near the bottom of the siding to the hold the panels together.
- Pull siding and batt material out toward the installer.
- Insert fill tube with the point to the interior surface between the insulation batt and interior wall.

- Push the fill tube to the top of the cavity.

- Pull the fill tube back slightly (6–12 inches) after hitting the top plate, window sill and or blocking and begin to insulate.
- Pull the fill tube back before the material moving through the hose comes to a complete stop.
- Use the existing or new insulation batt, cloth or foil ray to keep the insulation from falling out of the wall cavity.

- Insulate walls as feasible, install screws (new, longer, thicker screws if necessary)
- Check outlets and lights to ensure that they are still working. Do any repairs as necessary.
- Re-hang pictures and wall hangings.
- Some mobile home walls have $^1/_4$-inch cardboard Styrofoam behind the metal siding. If you find these types of walls, cut or punch a small hole (big enough for the fill tube in use) and insert the fill tube with the point to the interior surface to the top of the cavity and fill the cavity.
- Occasionally, mobile home sidewall siding is horizontal instead of vertical. If insulation is needed in these cavities, simply remove the bottom row of siding. Insert the fill tube between the insulation batt and the interior wall surface to the top of the cavity and fill the cavity. Re-install the siding when the insulation work is complete.

Mobile Home Floor Insulation

General Procedures

- Mobile home bellies with rodent barrier and insulation that are completely intact do not have to be insulated.
- Early results indicate that insulating mobile home perimeters may be more cost-effective than blowing insulation into the belly. Consider this option when whenever subfloor insulation is cost-effective.
- Mobile home bellies with areas of missing rodent barrier and/or insulation may have those void areas filled with at least R-11 blanket insulation material.
- ⌘The insulation blanket must be protected from degradation and secured in place. Areas directly under plumbing leaks may be left void so that moisture is not retained in insulation.
- Mobile homes that have more than 50% of the rodent barrier and insulation missing, or have plumbing leaks are good candidates for perimeter insulation. Follow guidance for installing perimeter insulation.
- Mobile home measures may be reported in the E$P Database if more than 100 square feet of the belly or perimeter are insulated by the agency.

In some cases blowing insulation into mobile home bellies make more sense. For example, if much of the skirting is missing, or if blowing belly insulation would be cheaper than insulating the perimeter.

Stuff and Patch

Where there are holes in the rodent barrier and small areas of missing insulation simply stuff a piece of batt insulation, that is larger than the hole, into the belly. Patch the hole.

Mobile Home Perimeter Insulation

This method is still under development, but preliminary results are encouraging. This measure will not be affected by leaking plumbing, which is a problem that shortens the life span of belly insulation. It also appears to be effective in reducing energy consumption. The key is for crews to learn how to install the measure quickly. Some agencies have learned how to install this measure quickly.

- ⌘Perimeter insulation must be durable. This is the reason for using 6ml plastic sheeting to protect it from moisture and from critters.
- ⌘Perimeter insulation must enclose the entire area under the mobile and stop air movement.
- Costs for this measure can be held down by using unfaced fiberglass blanket or MBI type insulation.
- ⌘The insulation blanket must be long enough to at least touch the ground. Excess insulation may be folded along the bottom edge, toward the interior.
- The key is for crews to develop a system for quickly installing the material.

- Lay out 6ml. plastic sheeting that is wide enough to wrap around the insulation blanket.
- Place the insulation blanket on top of the plastic and fold it over. Staple or tape the seam along one edge so that the seals the insulation within.

- Remove the skirting and staple the sealed seem to the rim joist.
- It is also possible to drag the insulation in underneath the mobile and then staple or secure it in place with lathe.

- In areas that are hard to access, a rope can be attached to one end and the material can be pulled through.
- Be creative and come up with your own method.
- Make smaller sections of insulation. Place them at the

access entry way so that can be easily lifted out of the way, but fall back into place.

Blowing Mobile Home Bellies

Blowing mobile home bellies has proven to be expensive, and not as effective as originally thought. Low quality plumbing is known to shorten the life of the measure.

⌘Belly insulation should only be considered if:

- The plumbing is in good condition,
- and the home has a high heating load and/or high cost fuel,
- and there are no other cost effective major measures to install (i.e. Ceiling insulation, wall insulation, high efficiency furnace installation),
- or the mobile home has a flat belly.

In the cases where mobile home belly insulation is the best option, there are three common methods of blowing insulation into the belly cavity:

1. Wing blow (transverse floor joists),
2. Blowing from underneath, and
3. Blowing through the rim joist from both ends of the home (longitudinal floor joists).

Preparing for mobile home floor insulation

⌘Prior to installing floor insulation, always perform these repairs:

- Repair plumbing leaks.
- Tightly seal all holes in the floor.
- Inspect and seal ducts.
- Install a ground-moisture barrier if necessary.

- Identify any plumbing lines, and avoid installing insulation between them and the living space. This may require running a piece of belly-paper under the pipes, and insulating the resulting cavity, to include them in the heated envelope of the home.

Fill tube inserted into belly hole

Wing blow

- Remove trim and skirting as necessary to access the wing area.
- Cut, or knock a hole into the belly at the wing as close to the rim joist as possible.
- Set machine settings according to the size of the fill pipe being used. Adjust insulation blower to open-blow settings so as not to clog the hose and desired density is obtained.

Fill tube inserted into belly hole

Holes patched with belly paper
Holes patched with belly paper

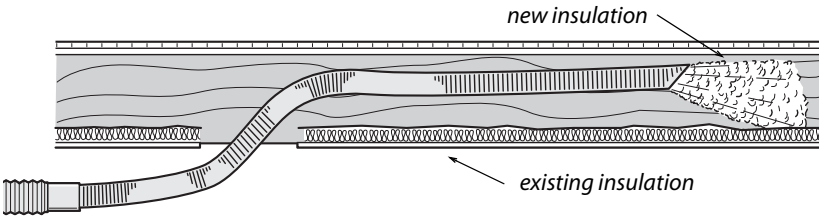
- Install 2-inch muffler or copper pipe into the cavity.
- Ease the rigid pipe into the cavity until it hits the other side of the rim joist, avoiding the duct.

- Mark any cavity with duct tape that can't be insulated from the wing.
- Pull the pipe back a foot or less and begin to fill the cavity.
- Pull the pipe back as the cavity fills.
- Fill any cavities and or portions of cavities from underneath with a fill tube that could not be blown through the wing access hole.
- Patch the access holes with belly paper/material with adhesive and staples as necessary.
- Self inspect belly while equipment is set up. Insulate any areas that were not insulated.

Belly blow from underneath

- Access the belly through an access or remove skirting as needed.
- Set settings according to the size of the fill tube being used.
- If the belly is a drop pan belly, cut, knock or drill an access hole into the cavity. Blow from the wing area to ensure that the wing cavities are filled.
- Insert the fill tube into the hole and push it up over the I-beam toward the center of the belly and begin to blow.

- Pull the fill tube back as the cavity fills; the material will slow down as the cavity fills. Push and pull the fill tube to dense pack the wing areas if desired.
- When blowing through holes from underneath the home, consider blowing through damaged areas before patching them.
- Turn the fill tube towards the opposite direction (to the rim joist) and fill the remainder of the cavity.



Blowing bellies: A flexible fill-tube, which is significantly stiffer than the blower hose, blows fiberglass insulation through a hole in the belly from underneath the home.

- Continue insulating along the wing areas until the entire belly is insulated.
- Patch the access holes with belly paper/material with adhesive and staples as necessary.
- Self inspect belly while equipment is set up. Insulate any areas that were not insulated.
- Note: If the belly is flat come in whatever length the fill tube is (10 feet) from the end: cut, knock or drill access hole in each cavity and push the fill tube toward the end of the mobile. It should reach the end rim joist. Pull the fill tube back 6–12 inches and begin to blow.

Rim blow through rim joists

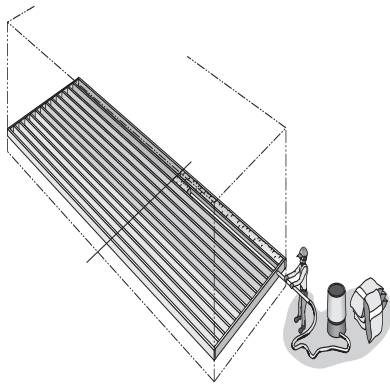
⌘This method shall only be used when blowing lengthwise joists. Use the Wing Blow, or other method for crosswise joists.

- Remove screws at the bottom of the skirting.
- Pull siding and trim piece (usually stapled) away from the frame.
- Remove trim piece and put it out of the way so it does not get damaged.
- Drill into each cavity with a self-boring bit or hole saw.
- Set machine settings according to machine and size of pipe.
- Install muffler or copper pipe into the cavity.
- Ease the rigid pipe into the cavity until it reaches the other side.

Drill holes carefully using good drill and sharp bit. Hold the drill with two hands.

- Pull the pipe back a foot or less and fill the cavity. If a more dense pack is desired at the wings, push and pull the pipe to pack the insulation into the cavity.
- Pull the pipe back as the cavity fills.
- Mark any cavity with duct tape that can not be insulated from the rim so it can be insulated from underneath.
- Fill any cavities portions of cavities from underneath that could not be blown through the rim.
- Seal the drilled holes with wood plugs and adhesive.

- Re-install the trim piece and screws (use longer, thicker screws if necessary)
- Self inspect belly while equipment is set up. Insulate any areas that were not insulated.
- Note: Rim joists may not be drilled if they are determined to be a structural component of the foundation support system, or if floor joists are 24 inches or greater on center.



Drilling through the rim joist: Mobile homes have either lengthwise or crosswise floor joists.

- Blown fiberglass is recommended over cellulose for either method.
- First repair all holes in the belly. Use mobile home belly-paper, silicone sealant, and stitch staples. Use these same patches over the holes cut for fill-tubes. Screw wood lath over weak areas if needed.

7.4 Exterior Water Heater Closet Treatment

- ⌘Repair any plumbing leaks,
- Replace the floor in the water-heater closet as necessary.
- ⌘Seal any large holes between the closet and interior.
- ⌘Install a collar at the vent, if necessary.
- ⌘Install combustion air in floor, use hardware cloth to keep rodents out. Obtaining combustion air through the door should only be considered as a last option.

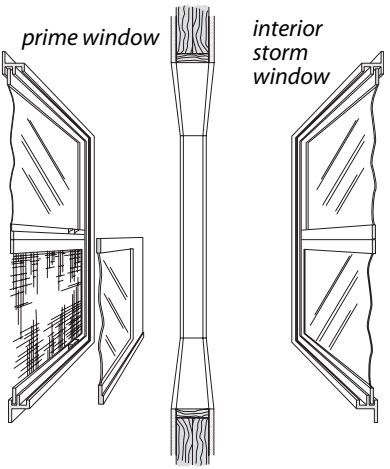
- ⌘Install a jacket on the water heater, if the tank R value is less than 7 for gas, and 11 for electric. Or use the "warm hand test".
- ⌘Install insulation on door.
- ⌘Insulate any water pipes susceptible to freezing.

Mobile Home Windows and Doors

Replacing windows and doors is generally not cost-effective and should only be done if repairs cannot hold the window or door together any longer.

⌘New jalousie or awning windows are not allowed as replacements.

Replacement windows with an emergency release are available, and one of these should be considered for bedrooms when replacing windows.



Mobile home double windows: In mobile homes, the prime window is installed over the siding outdoors, and the storm window is installed indoors.

Mobile Home Storm Windows

- ⌘Storm windows are a required measure, if they are cost-effective to install.
- Interior storm windows are common in mobile homes. These stationary interior storms serve awning and jalousie windows.
- Sliding interior storm windows pair with exterior sliding prime windows.

- Interior storm windows double the R-value of a single-pane window. They also reduce infiltration, especially in the case of leaky jalousie prime windows.
- Avoid replacing existing storm windows unless the existing storm windows cannot be re-glazed or repaired.
- When sliding primary windows are installed, use a sliding storm window that slides from the same side as the primary window. Sliding storm windows stay in place and aren't removed seasonally, and are therefore less likely to be lost or broken.

Replacing Mobile Home Windows

- Inspect condition of rough opening members before replacing windows. Replace deteriorated, weak or water-logged framing members.
- Prepare replacement window by lining the perimeter of the inner lip with 1/8-inch thick putty tape. Caulk exterior window frame perimeter to wall after installing window.

Mobile Home Doors

- Mobile home doors come in two basic types: the mobile home door and the house-type door. Mobile home doors swing outwardly, and house-type doors swing inwardly.
- ⌘Door replacement is an allowable expense only when the existing door is damaged beyond repair and constitutes a severe air-leakage problem.

7.5 Mobile Home Skirting

- Adding skirting is not cost-effective as an energy measure.

- Skirting may be added as a necessary repair to protect belly insulation, if it is cost-effective. (See the appropriate generic priority list).
- Insulating skirting is allowed if a large amount of belly insulation is missing, and it is not possible to repair and insulate the belly.

7.6 Completing the Job

Cleanup is a very important part of the job. It will leave a lasting impression on the client and it will affect how they think about the work that was done and the program in general.

Job site cleanup:

- ⌘Clean up well after completing the work.
- ⌘Dispose of potentially contaminated materials properly.
- ⌘Never leave broken glass or potentially dangerous debris at a clients home.

Complete self-inspection:

- ⌘Double check your work. Have a second person check the work. Make sure all work meets quality requirements.

See "Final Inspection" on page 33.

Wrap up:

- Tools, materials and equipment should be accounted for and put away properly.
- Ask the client if everything went well, if work quality and cleanup was satisfactory.
- Thank the client for their cooperation.

See "File Review and Completion" on page 34.

Insulation Density/Coverage Example

Consider a 14′x 66′ mobile home = 924 square feet.

- ceiling = 9″ cavity at the center and 2″ cavity at the edge w/a 2″ batt
- belly = $5^1/_2$″ cavity at the wings and $16^1/_2$″ cavity at the center with a 2″ batt fastened to floor bottom
- walls = $3^1/_2$″ cavity with a $1^1/_2$″ batt at $7^1/_2$′ high

General formulas

CAVITY VOLUME X DESIRED DENSITY = WEIGHT OF INSULATION

WEIGHT OF INSULATION ÷ POUNDS PER BAG = BAGS OF INSULATION

Ceiling bag count estimates for Thermacube Insulation

1. Calculate the average ceiling cavity (9″ + 2″ = 11″) (11″ ÷ 2 = $5^1/_2$″ average cavity)
2. ($5^1/_2$″ cavity minus the 2″ batt = $3^1/_2$″ cavity). The existing insulation batt will compress when additional insulation is added, allow 1″ for compression ($3^1/_2$″ + 1″ = $4^1/_2$″ cavity)
3. Convert $4^1/_2$″ to feet (4.5″/12″ = 0.375′)
4. Multiply 0.375′ x 924 sq. ft. = 346.5 cubic feet
5. Multiply cubic feet by desired density: Fiberglass ceiling insulation density must be 1.0 to 1.5 lbs/cubic foot.

a. 347 x 1.0 = 347 lbs. / 35(lbs/bag) = 9.9 bags

b. 347 x 1.25 = 434 lbs. / 35(lbs/bag) = 12.4 bags

c. 347 x 1.5 = 521 lbs. / 35(lbs/bag) = 14.9 bags

d. 767 x 1.5 = 1151 lbs. / 35(lbs/bag) = 33 bags

CHAPTER 8 E$P PLUS

8.1 E$P PLUS FURNACE REPLACEMENT FOR ENERGY EFFICIENCY

⌘Forced air gas furnaces that will be replaced with funding provided under HB1200 must meet the following criteria:

- Eligibility requirements are the same as that of the LEAP or Weatherization programs.
- Priority should be given to clients with high space heating costs. Home owners and renters should be treated equally if the rental properties have adequate third party contributions.
- Energy consumption levels must be used as a qualification criteria for furnace replacements. Use the information in the chart at the end of this section determine when it is cost effective to replace a furnace.
- A high efficiency furnace must be considered when replacement is being done for Health & Safety reasons. Only the incremental cost increase will be used in the economic analysis.
- All furnaces manufactured before 1982 may be considered for replacement.
- Any furnace with an AFUE (Annual Fuel Utilization Efficiency) that is 70% or less may be considered for replacement. The efficiency of the existing furnace must be determined and documented in the client file. AFUE may be determined by one of the three following methods:

1. Information obtained from the manufacturer's name plate.
2. Information located in an authoritative source, such as "Preston's Guide".

3. Performing a SSE (Steady State Efficiency) test and reducing that result by 10% if the furnace has a standing pilot light and a draft hood.

- Mobile home furnaces manufactured prior to 1982 may be considered for replacement. Mobile home furnace that were manufactured from 1982 until 1988 must have their AFUE determined by locating it in an authoritative source, such as "Preston's Guide". Mobile home furnaces manufactured after 1988 may not be replaced.
- Furnaces should not be installed in homes whose useful life is less than 20 years. Agencies must have language in their "Walk Away" policy that provides guidance on how to assess the useful life of the home. Agencies must be careful to document the conditions that would constitute a home with a useful life of less than 20 years.
- Any LPG fired furnace with a standing pilot and draft hood may be replaced with a sealed combustion furnace with electronically controlled ignition.
- Any LPG fired furnace with an AFUE of 70% or less may have a corn/pellet stove installed as an additional heat source if:

a. The client is willing and able to cope with the solid fuel.

b. The cost per therm of solid fuel is substantially cheaper that of LPG.

c. The solid fuel is readily available in the area.

d. The corn/pellet stove is likely to be the primary heat source.

e. The AFUE of the corn/pellet stove is greater than 79%.

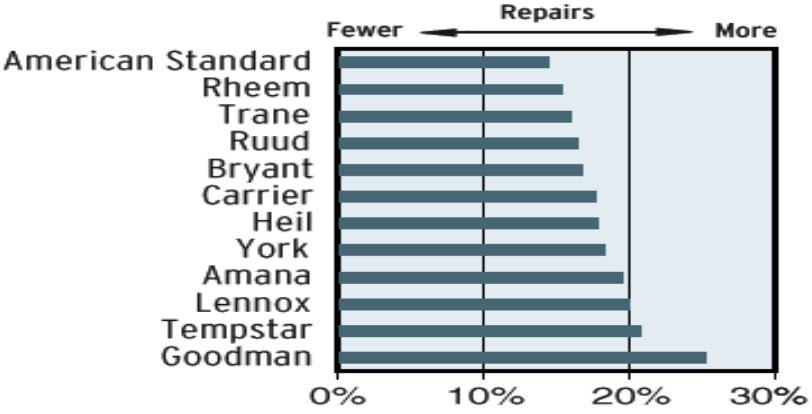
- Agencies may not install corn/pellet stoves if they are replacing the furnace.
- The owner of a rental property must contribute at least half the cost of purchasing the new furnace. Owner con-

tributions will be used to directly offset the cost of the furnace installation.

- Agencies must consider installing furnace with an AFUE of 90% to 92% before considering furnaces with a lower AFUE. Furnaces with an AFUE of 80%+ may be considered if more efficient furnace are not feasible or not cost-effective. All replacement furnaces must have an AFUE of at least 80%.
- Follow furnace manufacturers installation instructions.
- Follow local codes requirements.
- Check the ducts for air leakage and seal the leaks.
- A qualified inspector must inspect the furnace installation.
- Agencies must provide at least a two year warranty on the new furnace.
- New furnaces for site- built homes must carry a five year warranty on parts and a fifteen year warranty on the heat exchanger.
- New furnaces for mobile homes must carry at least a two year warranty on parts and a ten year warranty on the heat exchanger.
- Unvented space heating appliances may not be installed.
- The furnace repair history for new furnace installations must be considered when purchasing furnaces and preference must be given toward purchasing furnaces with the lowest repair history rate. Furnaces with repair rate histories that are greater than 18% may not be purchased. See: http://www.consumerreports.org/cro/home-garden/heating-cooling-air/furnaces-repair-history-205/overview/index.htm

	Winter Home Heating Energy				Furnace Efficiency	
	Six Month Bill			Annual	80%	90%
Therm Cost	$0.75	$0.87	$1.01	Therms Used	Install furnace if the cost is less than:	
	$522	$574	$654	700	$1,000	$1,700
	$560	$615	$701	750	$1,200	$2,000
	$597	$656	$748	800	$1,400	$2,300
	$634	$697	$794	850	$1,600	$2,600
	$672	$738	$841	900	$1,800	$2,900
	$709	$779	$888	950	$2,000	$3,200
	$746	$820	$935	1000	$2,200	$3,500

Find the agreed price for the new furnace under the appropriate furnace efficiency. Find either the therms used or the six month billing amount on the same line as the furnace price. This is minimum heating load required to be cost effective. Example: The 6 month heating bill for a home was $650. The average therm cost over those 6 months was $.87. The price agreement is $1500 to install an 80% furnace and $1850 to install a 90% efficiency furnace. It would be cost-effective to install the 90% furnace, but not the 80% furnace. An 80% efficient furnace would be cost effective to install if the heating load were 850 therms or more.



Furnace Repair History

Refrigerator Assessment and Replacement

General Requirements

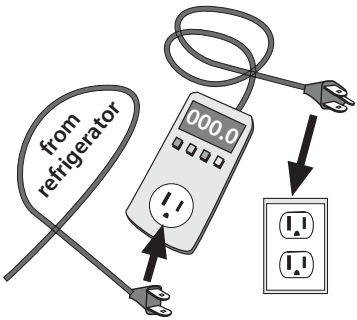
- All refrigerators must be evaluated for replacement.
- The results of the evaluation must be documented in the client file.
- Only operating refrigerators and refrigerator -freezers may be replaced.
- Agencies may replace two existing refrigerators with one, larger energy-eFficient refrigerator
- Individual refrigerators may only be replaced with a new refrigerator that meets the cost-effective criteria (SIR) of 1.2.
- Agencies may consider the replacement of two refrigerators, or a refrigerator and a freezer, with a new high efficiency refrigeration appliance that meets an SIR of 1.2 when the energy load of both appliances being replaced are factored into the analysis.
- Refrigerators that are not metered must be analyzed with the NEAT computer audit, or other approved methodology.
- All refrigerators whose manufacture information cannot be determined must be metered.
- Eligible refrigerators are those functioning appliances that meet the SIR criteria for replacement, and can reasonably be accessed for removal and replacement.
- The owner of eligible refrigerators must sign the E$P Refrigerator Replacement agreement, and must comply with the terms of that agreement, including relinquishing ownership of the old appliance at the time of delivery of the new appliance. Landlords who own eligible

refrigerators must contribute 50% of the total cost of replacement.

- Agencies must meter at least 10% of the refrigerators that are replaced. The minimum time duration of the metering is a two hour period, uninterrupted by a defrost cycle. If the defrost timer cannot be advanced, a meter capable of detecting the defroster run time must be used to meter for a minimum of 3 hours.
- Agencies must retain in the client file the E$P Terms and Conditions for Refrigerator Replacement form. The form must be signed and dated by the appliance owner and the agency representative.
- Agencies must retain in the client file information from the existing refrigerator detailing the make, model number, size, age, kilowatt hour usage, and if it was metered or found in the AHAM database.
- The make and model of the new refrigerator must also be retained in the client file, along with verification of delivery of the appliance.
- Agencies may use all or part of the $150 per home repair waiver toward correcting problems associated with refrigerator replacement.

Metering Protocol

Read and follow the metering instructions for your particular kilowatt (kWh) meter.

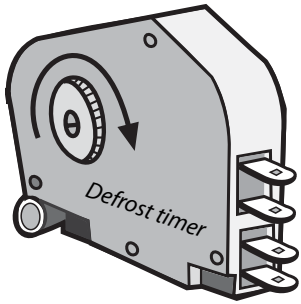


⌘A minimum of 10% of the refrigerators which are considered for replacement must be metered, including all those in which the manufacture information cannot be determined.

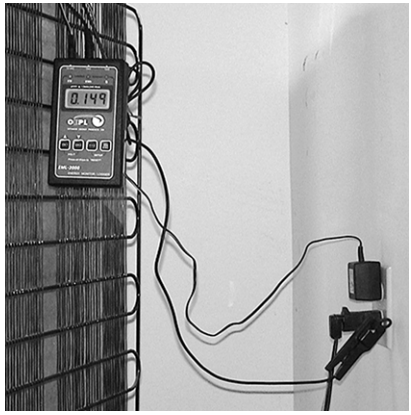
- ⌘The metering period is a minimum of two (2) hours.
- ⌘The defrost cycle must not activate during short term metering. Therefore it is necessary to de-activate the defrost timer before starting to meter.
- Locate the defrost timer (usually inside a removable mounting box) on the back of the appliance, inside refrigerator next to the light panel, or behind the bottom front kick-plate.
- Advancing the defrost timer is not necessary if your equipment is capable of accounting for and removing electricity used during the defrost cycle.⌘ In this case the metering period is a minimum of three (3) hours.
- Advancing the defrost timer is not necessary if your equipment is capable of accounting for and removing electricity used during the defrost cycle.⌘ In this case the metering period is a minimum of one (1) hour.
- ⌘Check the electrical outlet to make sure that it is grounded and that the voltage is adequate.
- If the outlet is not grounded, check to see if the outlet box is grounded. If it is, it will be possible to ground the

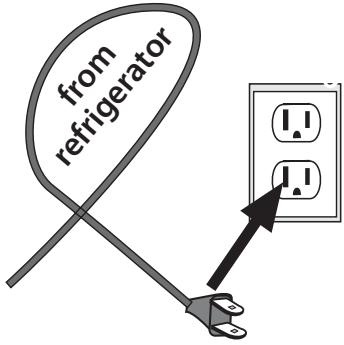
outlet to the box. A three prong adapter with a ground wire that is grounded to the box may also be used.

- Some plug-load meters provide for removal of the defroster spike. In the Payback calculator window, the user may select a "range of data" to be analyzed, thereby eliminating any unwanted spikes from the analysis.



- Advance the defrost timer manually using a screwdriver and turning the pinion clockwise (do not turn counter-clockwise this may damage the timer) until you hear a loud click (this is the beginning of the defrost cycle) continue to turn clockwise unit you hear a loud second click (this is the end of the defrost cycle) you are now ready to begin short term metering.





- If you experience any problems metering an appliance contact your supervisor immediately.

- Document all pertinent information on the proper forms.
- Use the refrigerator replacement chart to determine if it is cost effective to replace the refrigerator.
- **Plug the refrigerator back into its outlet.**

Tool list

1. Electrical circuit analyzer
2. kWh plug-load meter
3. Pen/pencil and Refrigerator Replacement Form
4. Flashlight and pocket calculator
5. 3 to 2 way electrical adaptor
6. A piece of carpet or cardboard for moving the appliance

Client responsibilities

- ⌘An adult must be present (over 18 years age) at time of delivery to sign for receipt of the new refrigerator.
- The client must empty the old refrigerator of all foods and create a clear path for removal and delivery of the appliances.
- The client must have a phone, or access to a phone for scheduling.
- The client is responsible for cooling of any foods during the first 24 hours (stabilization period) after delivery of the new refrigerator.
- Appliances scheduled for pick-up and removal must be available at the time of delivery, or the delivery of the new refrigerator will not be made.
- ⌘Families may not keep their old refrigerators. The old refrigerator must be removed when the new appliance is delivered.

- ⌘Landlords will be responsible for a co-payment of 50% of total costs before the order will be placed.

E$P Plus Pilot projects

Potential Pilot Projects:

- Evaporative cooling to replace window mounted air conditioners.
- High-efficiency hydronic space heating systems in place of multiple forced air or convection heating systems.
- High efficiency tank type water heaters.
- Tankless water heater installations may be considered on a very limited basis. These systems typically have high maintenance costs which must be factored into both the life cycle cost analysis and the clients ability to pay for these costs.
- Renewable energy space or domestic water heating systems.
- Other measures that have a good potential for cost-effectively reducing client energy consumption.

Pilot Project Proposals

- ⌘The project must be submitted to the E$P Energy Services staff for review and approval prior to starting an E$P Plus pilot project.
- ⌘Agencies will work with state staff on cost and energy savings estimates.

General Components of a Pilot Project

Research

- Find measured savings from past evaluations.

- Look for savings estimates from various sources.
- Determine which variables impact the SIR of the project. Typically these variable include fuel costs, energy consumption levels, existing appliance efficiency, replacement appliance efficiency, local climate, and installation cost.
- Look for products that are available in your area.
- Determine if the products are appropriate for your clients. Appliances should be as energy efficient as feasible. Appliances should have low maintenance requirements and life cycle costs. Appliances should have high reliability.
- Obtain prices and efficiency levels for various models and brands, if possible.

Estimate Savings to Investment Ratio

- Modify measured or estimated savings to match local conditions.
- Based on estimated costs and savings, estimate an SIR for measures installed within the scope of the pilot.

Put the Proposal Together

- Clearly explain what you want to do.
- Explain why you believe that it will be cost effective.
- Give a time frame for each part of the proposal.
- Set a specific target number of pilot measures to be installed.
- Include a budget that details the costs for installing the measures and for conducting the research and evaluation portion of the pilot.

Job Data Collection

- Collect data on the existing conditions and/or appliance efficiency.
- Obtain energy use information from the utility before starting the work.
- Collect and compile information on the cost of the installation of the measure.
- Collect and compile information on problems, special tools, new techniques, or other situations that would be helpful to others.

Evaluation

- Pilot projects should include an evaluation of the general feasibility of the measure, as well as actual performance measurements.
- Use short term monitoring to collect data on the performance of the measure savings.

or

- Use short term energy use analysis to determine the performance of the measure.
- Use long term energy consumption data to evaluate savings at least one season after completing the pilot.

Final Report

Prepare a brief Final Report that contains:

- A Summary of the pilot and the results.
- An explanation of the procedures that were used.

- Pictures taken during the installation process.
- A brief explanation of useful experiences gained during the pilot.
- Conclusions on the success of the project.
- Recommendations on how, or if the measures evaluated during the project would be implemented on a large scale basis.