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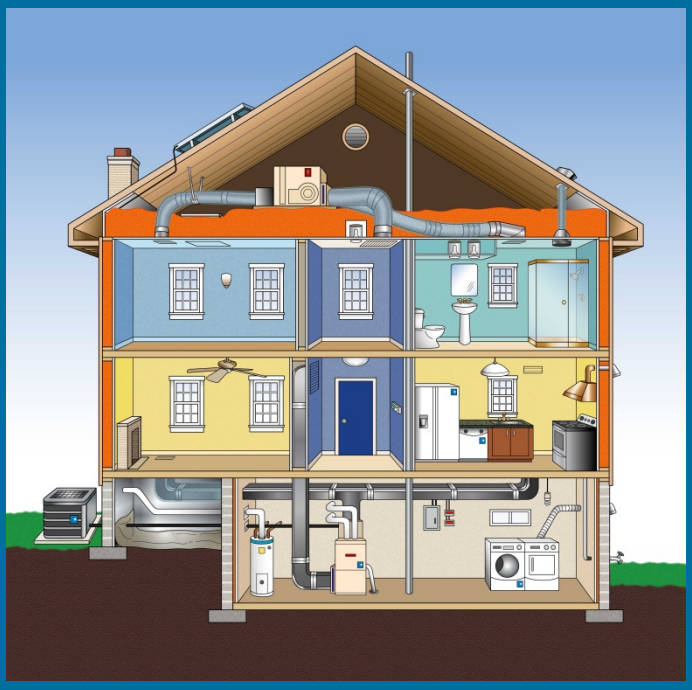
NYSERDA

Residential Existing Homes Programs Material and Installation Guidelines



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Acknowledgments

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Additional thanks to the many contractors, consultants and staff who have contributed to the development of this document.

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1. Introduction

1.1 Purpose

This Material and Installation Guidelines (MIG) is designed to provide the materials and installation requirements for installing energy efficiency measures in NYSERDA's NY Residential Existing Homes Program (The combined programs NY Home Performance with ENERGY STAR®, Assisted Home Performance with ENERGY STAR®, and EmPower New York, collectively the "Program"). It is intended to assist participating contractors, field staff, quality assurance inspectors, quality control inspectors and management in ensuring consistent quality of installed work.

The guide is based on the concept of "Standard Work Specifications" (SWS). These are the minimum expectations for meeting the requirements for quality installation of the measure. In many instances the MIG does not dictate the exact techniques to be implemented, leaving the contractor to determine the best approach. Optional best practices and recommendations are offered to assist contractors in effective installations.

The guidelines set forth in this document establish the basis of quality for work performed within the program. To ensure compliance, participating contractors are responsible for adhering to these guidelines. Completed projects are subject to inspection by NYSERDA's third-party Quality Assurance contractor. In-progress projects are subject to review by the Implementation Contractor or NYSERDA staff.

This guide also provides effective techniques for contractors who provide energy efficiency services outside of the Program, and contractors are encouraged to follow these guidelines in all of the work they perform.

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1.2 Program Specific Content

The Material and Installation Guidelines do not provide program eligibility information. All questions or concerns regarding Program Requirements, and the use of this MIG may be directed to the Implementation Contractor. All requirements in this document apply to measures that are listed on the Program's lists of eligible measures.

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2. Work Related Standards & Regulations

All contractors must perform their work in compliance with all applicable codes, regulations, laws, and standards in the jurisdiction where completing work. In instances where this manual may conflict with state and/or local code or manufacturer's requirements, code or manufacturer's requirements must take precedent. If there is any variation between code and manufacturer's requirements, the more stringent standard must be followed. In all instances where specific code citations are included in the manual, current code, if revised, takes precedence over citations in this document.

1. It is the contractor's responsibility to verify pre-installation conditions, and measurements of insulated areas, and to install measures according to these specifications. Any discrepancies must be resolved before work commences whenever possible.
2. All contractors must comply with their company's health & safety specifications.
3. All contractors must maintain a copy of their company health and safety policy at the work site. Contractors must supply a Safety Data Sheet (SDS) for products and materials used by their crews to customers and Program staff upon request.
4. Work area must be cleaned daily by sweeping and disposing of debris and scraps in a location designated by the owner. Upon completion of the work in any given area, the contractor must remove tools, equipment, and all rubbish and debris from the work area and leave area in broom-clean condition.
5. Waste such as dust, trimming, packaging and chemical cylinders must be disposed of in accordance with applicable federal, state and local regulations.

○*OPTIONAL BEST PRACTICE*○ Walk the entire job with the Homeowner to ensure that all aspects of the job are completed to agreed-upon standards.

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2.1 Personal Protection & Work Site Air Quality

2.1.1 Employee Safety

- The contractor must perform all work in a safe manner and utilize appropriate personal protection measures.
- The contractor must maintain a copy of its health and safety policy and treat all employees accordingly.
- Adherence to applicable OSHA standards is required for all jobs conducted through the Program.

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2.1.2 Occupant Safety

Any negative impact an installation may cause upon the health and safety of the occupants and the structural integrity of the building must be avoided. Contractors must comply with all local, state and federal regulations governing potential hazardous materials or situations. Contractors must evaluate existing conditions and communicate potential problems to the customer so that problems may be addressed before beginning work. This includes the identification of possible indoor air contaminants, severe moisture problems and potential back-drafting of combustion appliances.

○*OPTIONAL BEST PRACTICE*○ Keep extra copies of the Safety Data Sheets (SDS) in work trucks and provide them to customers upon request or in situations when customers express concerns about the materials to be installed.

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2.2 Presumed Asbestos Containing Material (PACM)

2.2.1 Definition

Asbestos is a fibrous mineral used in thousands of building products. This mineral, when broken down, forms microscopic fibers that persist in the air and can be inhaled. These asbestos fibers are known to cause debilitating and sometimes fatal lung diseases. Asbestos-containing building materials are typically classified as either friable or non-friable and contain greater than 1% of asbestos. The goal is to ensure that any work performed at the home will not damage asbestos-containing materials and that the safety of the occupants and contractor's workers are protected. Materials can only be termed "asbestos" if testing has been done to confirm the presence of asbestos in the material. In the absence of such testing, contractors must not use the term "asbestos" when describing suspected materials. Instead, the term "Presumed Asbestos Containing Material" (PACM) should be used.

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2.2.2 Requirements

The presence of PACM in building materials that is damaged or in a deteriorating condition ("friable") disqualifies the home from blower door tests, duct pressurization tests or any activity that could potentially introduce asbestos fibers into the living space. Friable asbestos-containing materials, which are not intact, can become a source of airborne asbestos if the material is disturbed by movement or air currents. Friable asbestos-containing building materials may be found in vermiculite, boiler and pipe insulation/fittings furnace distribution systems, and other locations. Blower door tests that either pressurize or depressurize a dwelling must not be conducted if friable PACM are not intact and are at risk of being drawn into the living space. Vermiculite, used as loose fill insulation, is presumed to be asbestos-containing and should not be disturbed. For additional information on asbestos and vermiculite insulation, please reference the EPA at:

http://www2.epa.gov/asbestos

The presence of PACM does not automatically disqualify a home from all weatherization work unless the proposed work causes the potential for PACM particles to become airborne through activities such as sawing, drilling or other construction activity or if the existing building material is damaged. Examples of asbestos-containing building materials that are typically less likely to be friable include, but are not limited to, cementitious house siding, roof shingles, fire-stop boards, floor tiles, linoleum, flue pipes and chimneys. Under no circumstances should the contractor saw, cut, break, tear, sand or drill PACM in the performance of any work. Note: If any cementitious siding deemed PACM is damaged during removal it must be handled and disposed of in accordance with all applicable regulations.

If a contractor is not sure if a building material is asbestos-containing, then they should deem it PACM and not disturb the material. If potential hazards cannot be avoided in complying a measure, such as potential worker exposure to friable PACM, the contractor or Program may elect not to complete the measure.

Blower door and applicable retrofit work may proceed in circumstances where friable PACM is remediated by a certified asbestos abatement contractor who has attested to its remediation in writing.

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2.3 Knob-and-Tube Wiring

2.3.1 Definition

Knob and Tube wiring may be found in pre-1950 buildings. It is a style of wiring that has two separated strands of insulated wire that run through ceramic tubes when passing through framing members and ceramic knobs when attached to a framing member. When electricity flows through the wires there is resistance to the passage of the electrons. This resistance builds up heat that is dissipated to the surrounding space.

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2.3.2 Requirements

If active knob and tube wiring is determined to be present in a home, no insulation or air sealing materials may be installed within three inches of any live knob and tube wiring. The knob and tube wiring must either be decommissioned or removed by a licensed electrician, or accommodation must be made to ensure that any and all installed insulation or air sealing materials not installed within 3 inches of the existing knob and tube insulation.

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2.4 Mold-Like Substance (MLS)

2.4.1 Definition

Mold is an organic substance that has been shown to cause adverse health effects in some individuals. Contractors must not characterize a moldlike substance as "mold" unless a determination has been made by a certified mold inspector. Instead, the term "Mold-Like Substance" (MLS) may be appropriate.

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2.4.2 Requirements

When a suspected mold-like substance is present, the homeowner should be informed and directed to consult the Environmental Protection Agency's "A Brief Guide to Mold, Moisture and Your Home".
Additional information may be found at:

https://www.epa.gov/mold/brief-guide-mold-moisture-and-your-home

When a mold-like substance is found to be present in an area of the home, and it exceeds an area greater than 10 sq. ft., air sealing and insulation work must not be installed until one of the following conditions have been met:

1. A certified mold abatement professional has remediated the mold and has attested to its remediation in writing.
2. A certified mold abatement professional has determined that the substance is not mold, does not need to be remediated and has attested to this determination in writing.

Exception: In situations where more than 10 sq. ft. of mold-like substance exists in the attic, contractors may proceed with measures that may impede mold growth in the attic, such as:

- Elimination of the source of moisture
- Air sealing and insulating the air barrier between the source of the moisture and the attic space where the mold-like substance was found. The contractor must not add insulation unless they can ensure that they have sealed all bypasses by which moisture may enter the attic. The use of Zonal Pressure Diagnostics to ensure comprehensive sealing is strongly recommended.
- Reducing the impact of central humidifiers that may be installed on furnaces and driving moisture into the attic. Ensuring comprehensive return duct sealing and ensuring that the furnace filter slot is sealed may reduce positive pressure in the conditioned space that can drive moisture into the attic.

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2.5 Lead Paint

2.5.1 Definition

Lead was a common ingredient in many paints up until its use was banned in 1978. Lead ingestion or inhalation of lead dust or particles has been shown to cause damage to the central nervous system. Children in particular are at a high risk for nervous system damage from lead exposure.

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2.5.2 Requirements

In any home built before 1978 there is a possibility that lead paint was applied to some or all surfaces. If specified work in the home will require cutting into areas that are potentially covered with lead paint the EPA Lead Safe Guidelines and all Lead Safe Practices as outlined in Title 40: Protection of Environment, Subsection 745.85 must be followed.

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2.6 Heat Sources

2.6.1 Definition

A heat source is any item, equipment, or material that produces heat at temperatures that has the potential to ignite combustible material.

Examples of heat sources include but are not limited to: space and water heating appliances, including wood and pellet stoves; metal combustion flue piping; metal and masonry chimneys; heat lamps.

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2.6.2 Requirements

Locations in close proximity to a heat source should be air sealed or insulated with fire-proof materials at a minimum to the distances required by Code from the heat source. Appropriate materials for this application are sheet metal and high temperature sealants (ASTM E136 for oil or wood flues, 500F RTV silicone for gas flues). The sheet metal must be applied over any openings that cannot be bridged by the sealants and mechanically fastened in place with nails, screws or staples. Gaps and leakage points around the sheet metal must then be sealed using the appropriate high temperature sealant.

All sealants must meet code requirements as noted above. Foam sealants intended for fire-blocking may not be fireproof, and therefore may not be suitable for air sealing around a heat source.

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2.7 Combustion Appliance Zone Safety

Combustion Appliance Zone (CAZ) safety screening or testing is required before and after air sealing or dense pack wall insulation is installed. If the installation of air sealing or dense pack insulation measures occurs over several days, CAZ testing must be done at the end of each day. All tests must be conducted using the Building Performance Institute (BPI) combustion testing procedures and all test results must be recorded and submitted to the Program.

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2.8 Indoor Air Quality

Measures that reduce air movement in the home must always be done in a manner that ensures the dwelling has sufficient fresh air for the occupants, and that the work performed does not increase the likelihood that the occupants will be exposed to pollutants.

This is done by:

1. Identifying pollutants in the home that may be impacted by air sealing
2. Whenever possible, removing the source of the pollutants or isolating them from the living space
3. Choosing air sealing strategies that ensure that fresh air is available throughout the home

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2.9 Radon

2.9.1 Definition

Radon is a colorless, odorless gas that in high enough concentrations has been shown to increase the risk of developing lung cancer.

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2.9.2 Requirements

The homeowner should be advised about the possible presence of radon and should be encouraged to perform a radon concentration test after any air sealing work is done. More information about the health risks associated with Radon can be found in EPA's "A Citizen's Guide to Radon" on their website.

Additional information may be found at:

https://www.health.ny.gov/publications/3168/

2.10 Gas Leak Testing

In dwellings where natural gas or propane lines or appliances are present, the contractor must test the ambient air for natural gas in all areas of the dwelling using a Combustion Gas Detector (CGD) suitable for testing ambient air and capable of detecting gas levels of 20 ppm. In the event that propane is in use in the dwelling, the contractor must test the ambient air in all of the lowest areas of the dwelling. When the CGD indicates that combustion gas exists in the ambient atmosphere (at *any* level below 10% LEL) the contractor must initiate gas leak testing on all gas lines and combustion appliances as per ANSI/BPI-1200-S-2017, Standard Practice for Basic Analysis of Buildings, Section 7.5.2. Testing must be completed prior to and upon completion of work.

The contractor must test all gas lines and combustion appliances as per ANSI/BPI-1200-S-2017 Standard Practice for Basic Analysis of Buildings, Section 7.5. immediately after the following situations:

- The contractor repairs, modifies or installs new natural gas or propane lines, connectors, or combustion appliances.
- The contractor has reason to suspect a gas leak.
- A gas meter is replaced
- An out-of-gas condition occurs

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3. Air Sealing and Insulation

3.1 Air Sealing Overview

Air leakage can be linked directly or indirectly to the most prevalent building envelope performance and durability problems. The best way to ensure adequate thermal performance, comfort and avoid moisture problems is to prevent air from uncontrollably flowing into and out of the occupied space of the building envelope. At the same time it is critical to ensure adequate fresh air throughout the dwelling for the building's occupants, both present and future.

The objective is to safely and cost-effectively control air leakage. This is accomplished by obstructing airflow through leaks, penetrations and bypasses that are found in the attic, basement, living space and exterior pressure boundaries as indicated by blower door tests and air sealing guidelines. The goal should be to provide a continuous, structurally supported plane of materials to contain the indoor air (reduce exfiltration) and to reduce the amount of outdoor air from entering the building (infiltration). While doing so, it is important to measure air leakage levels and consider the ventilation paths throughout the dwelling.

1. Air sealing strategies may include addressing building assembly transitions that are extensions of the building envelope into unconditioned spaces. These transitions include, but are not limited to, changes in substrate, perimeter and transition conditions, mechanical penetrations and mechanical system components.
2. The building envelope must incorporate a continuous air barrier system as per the International Energy Conservation Code.
3. The air barrier must be installed in a manner that meets the NYS Energy Code.
4. The air sealing materials must be selected and installed in a manner that will accommodate normal building movements.

This section defines the quantitative and qualitative requirements for the products, materials and workmanship for the air barrier system of the thermal envelope.

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3.1.1 Air Sealing Materials: Locations & Use

The following are requirements that apply to all air sealing material choices:

1. The proper caulking material should be matched to the location where it is applied. Consideration should be given to the durability, paint compatibility, adherence, color, toxicity and flammability of the material.
2. Applied sealant and blocking materials must be suitable for the working surfaces and be able to maintain a durable seal.
3. Siliconized acrylic materials should generally be used only in interior locations or in exterior locations where paint compatibility is important. When used in visible areas the customer should

approve the application and see a sample before proceeding. It is best to avoid clear acrylic materials due to their shiny appearance and their propensity to shrinkage. Siliconized acrylic materials should not be used to seal openings or cracks over 3/16 inch without a backer and generally should not be used to seal openings or cracks more than 3/8 inch.

4. Pure silicone should generally be used in exterior applications unless paint compatibility is needed. Pure silicone should be used anywhere that sealants are needed between wood and metal and wood and concrete. Also, pure silicone should generally be used to seal materials that expand and contract at different rates as moisture and temperature vary. Pure silicone should not be used to seal openings or cracks over 3/8 inch without a backer, and generally should not be used to seal openings or cracks more than ½ inch.
5. Caulking may be performed on the interior of the dwelling for general air leakage and to prevent moisture penetration into wall cavities.
6. Caulking may be performed on the exterior of the dwelling to prevent bulk moisture from entering the envelope of the building and to seal areas of air leakage.
7. 1-part and 2-part foam sealant:
    a. Foam sealant must not be used to seal gaps or openings spanning more than 1½ inch without a backer material.
    b. Foam sealant must not be used where it can be exposed to sunlight or other ultraviolet sources.
    c. Foam sealant must not be used near any heat-producing device.
8. Spray foam applied sealants must be installed according to manufacturer's specifications.

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3.1.2 Sealant & Blocking Materials

Caulking

All caulking materials must be rated for a minimum 20-year life span. Caulking used around chimneys must be rated for use against heat sources. Caulking used around gas flues or chimneys must meet ASTM C290. Caulk used around solid fuel or oil appliance vent flues or chimneys must meet ASTM E136. Siliconized acrylic caulks must be paintable.

○*OPTIONAL BEST PRACTICE*○ Apply products with ultra-low or no CFCs, and with minimal or no odor.

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2-Part Spray-Applied Polyurethane Foam (SPF)

All SPF materials must meet ICC ES AC 377 for the application. Refer to Appendices B&C for methods to correctly and safely install spray foam. Types of SPF include:

1. Open-cell polyurethane foam (0.5pcf)
2. Medium-density closed-cell spray-applied polyurethane foam (2.0pcf)

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Other Sealants
Other acceptable sealants include, but are not limited to, the following:

- Spray applied Latex Based Sealants
- Mastic

Examples of Materials for Use as Blockers & Backers

- Plywood
- Foam board
- Foil bubble-wrap or similar (to block large bypasses)
- Metal flashing materials (used for damming and to bridge gaps at chimneys and flues). Materials must be waterproof in area where susceptible to rust.
- Wallboard
- Glass or mineral fiber insulation as a backer for other sealants
- Backer rod (foam rope) used as a backer for other sealants. Closed cell backer rod is waterproof.
- 6-mil (0. l50 mm) polyethylene sheeting (waterproof)
- Cellulose or fiber glass insulation as used in a dense-pack application
- House wrap such as Tyvek™ or similar material

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3.1.3 Safety Checks Prior to Air Sealing

General Safety Check
During the initial assessment, the contractor must evaluate health and safety risks that may impact indoor air quality, such as:

- The presence of PACM or mold-like growth
- Wood stove particulates
- Tobacco smoke
- Home renovations which include materials such as plywood, particle board or new carpeting, that may outgas formaldehyde and other pollutants;
- Dryer or other appliances not properly vented to outside the building envelope.
- Other health risks.

Additionally, the contractor must assess moisture conditions in the dwelling that may be impacted by work to be performed, such as:

- Standing water in basements or crawlspaces
- Roof leaks
- Aquariums, hot tub, large number of plants within the thermal envelope
- Pre-existing damp insulation in the attic areas
- Occupant reports of high moisture levels

- Kitchen or bathroom fans venting to the attic areas, or otherwise not venting outside
- The use of a central humidifier on a furnace, particularly with leaky return ducts

In the presence of identified health risks that may increase if air sealing activities are implemented, the contractor must either:

- Discontinue or limit air sealing activities; or
- Initiate removal of the pollutants: or
- Air seal in such a manner as to isolate the pollutants from the living space, or
- Supplement natural ventilation with mechanical ventilation in such a manner that pollutants are reduced.

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Combustion Safety Pre-test

The air sealing technician must perform a combustion safety pretest before air sealing. The combustion safety pretest must include:

1. Fireplaces, wood stoves, coal stoves or other solid fuel appliances
2. Gas or propane cooking stoves
3. Gas, propane or oil water heaters
4. Gas, propane, or oil boilers, furnaces and unit heaters

The combustion safety pretest must follow the BPI 1200 and Program combustion pretest procedure which includes:

1. Ambient combustible fuel gases test - Section 7.3.2 of BPI 1200
2. Ambient Carbon Monoxide (CO) readings and actions - Section 7.3.3 of BPI 1200
3. Natural Gas and Liquid Propane (LP) gas leak testing – As per Section 2.10, above
4. Check unvented Gas Fired Room Heaters - Section 7.8.4 of BPI 1200
5. Spillage Assessment and CO Measurement in cold vent (Except domestic water heaters) - Section 7.9.2 of BPI 1200
6. Spillage Assessment and CO Measurement in domestic water heaters or warm vent - Section 7.9.3 of BPI 1200
7. Carbon monoxide levels in flues (undiluted)
8. Zone pressures created by exhaust appliances
9. Zone pressures created by the duct system when the air handler is operating

○*OPTIONAL BEST PRACTICE*○ Draft pressure checks of venting systems for space and water heaters.

If there is any failure in the combustion safety pretest no air sealing shall be performed until the problem has been remedied.

Blower Door Pre-test
The air-sealing technician must prepare the house for a blower door pretest. Pressure differential readings must generally be used to detect substantial leakage paths and to determine the ratio of pressure differences across interior and exterior surfaces of a zone.

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3.1.4 General Air Sealing Procedures

Air sealing technicians must strive to seal all cost-effective leakage in the building. It is important to recognize that air sealing efforts may not result in immediate significant air leakage reductions; often a certain volume of holes must be sealed before air sealing efforts have an effect.

○*OPTIONAL BEST PRACTICE*○ If a blower door is used while air sealing, take hourly blower door readings to monitor the impact of air sealing. Work should terminate once cost-effective reductions have been achieved and all major areas of leakage have been addressed, while maintaining adequate ventilation of the conditioned space.

Before applying caulking and other sealants, remove dust, dirt or debris from the area to be sealed. Ensure that the area to which the sealant will be applied is dry. Follow any additional instructions in the manufacturer's installation guidelines and specifications before application. Be sure to take into consideration all temperature requirements related to the product and ensure that the products are installed in such a manner as to produce a strong, failure resistant bond.

Backer Materials fall into two general categories: Rigid and non-rigid.

- Rigid backers inserted into joist or stud bays may be held in place by friction and permanently secured by the adhesion of 1-part foam or caulk. Rigid insulation that seals drop soffits, large mechanical chases, etc. must be fastened in place using either nails or screws. Metal flashing can be held in place with box nails or screws.
- Non-rigid barriers (foil-faced bubble wrap, polyethylene, etc.) can be secured using ½ inch staples every 4-6 inches. Rolled fiberglass batts or mineral wool must be stuffed tightly into openings to ensure that they stay where intended.

Rigid foam board insulation that will be exposed to finished spaces must be covered with a thermal barrier. Rigid foam board insulation that will be exposed to an accessible area that is used for storage must be covered with a thermal barrier. Backer materials used in exterior wall applications must be waterproof.

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3.1.5 Air Sealing Post-Installation

Air sealing technicians must conduct a blower door test and combustion safety testing after all air sealing work is complete, unless conditions, such as the presence of damaged PACM or mold-like growth, preclude

their use. If there is any failure in the post-installation combustion testing appropriate corrective action must be taken.

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3.2 Attic Air Sealing

3.2.1 Definition

Attics are enclosed spaces outside of the intentionally conditioned living space. Air sealing measures for *conditioned* attic spaces are covered in the sections on walls and roof slopes.

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3.2.2 General

The following installation guidelines shall be followed to ensure that attic air sealing measures are effective and durable. The materials used in each descriptive application (See: *Locations and Use*) must be chosen from the list of appropriate materials. Alternative materials may be used as long as they have the same performance criteria as the listed appropriate materials (i.e. they are fireproof if fireproof materials are required). All attic air sealing applications must be able to support the weight of existing and proposed insulation. Additional support must be added as needed. No backer material must exceed a distance of 24 inches if unsupported.

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3.2.3 Locations and Use

Typical openings, cracks, gaps and penetrations to be air sealed in attics include, but are not limited to the following:

- Interior partitions and exterior wall top plates
- Along both sides of top plates, at butt joints and at intersections
- Along dropped ceilings and soffits
- Junction boxes and wiring penetrations
- Open joist bays in knee-wall attics
- Hatches and pull-down stairs
- Wet walls and plumbing chases/penetrations
- Mechanical system components (also see Heating and Cooling Systems)
- Chimneys and flues
- Duct penetrations
- Whole-house fan enclosures
- Bathroom fans and recessed light fixtures

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3.2.4 Material

Backers

Backers consist of any material that is used to bridge openings that cannot be closed solely by a sealant. The following is the list of backers that are appropriate to use in attics air sealing applications:

1. Fire-proof Backers:
    a. Metal Flashing
    b. Mineral Wool
2. Fire-resistant Backers:
    a. Thermax
    b. Wallboard
    c. FSK rigid board
3. Moisture-resistant Bakers:
    a. 6 mil polyethylene or thicker
    b. Rigid foam board Insulation (extruded polystyrene)
    c. Foam backer rod
    d. Foil faced polyisocyanurate
4. Other Backers: (may be used when fire and/or moisture resistance is not a concern)
    a. House wrap
    b. Radiant bubble wrap
    c. Plywood
    d. Insulated structural sheathing

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Sealants

Attic Air Sealants are materials applied to attic surfaces and/or backers to form an air tight seal. The following is the list of sealants appropriate for attic use:

1. Fire-Proof Sealants:
    a. Non-combustible fire rated caulk meeting ASTM E 136
    b. Silicone high temperature RTV sealant meeting ASTM C920 on gas vents with flue temperatures up to 500 degrees Fahrenheit
2. Non-Fireproof Sealants:
    a. 1-part urethane foam
    b. 1-part urethane fire block foam rated for sealing gaps in wood framing
    c. 2-part urethane foam kits
    d. Siliconized latex sealants meeting ASTM C834
    e. Silicone urethane and other elastomeric sealants meeting ASTM C920
    f. Water-based duct sealant meeting UL181A-M, UL181B-M
    g. Spray applied latex based sealant

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Table 1. Compatible Attic Air Sealing Materials

(Note: This table lists effective combinations of backers, fasteners, and blockers. Other combinations are possible.)

Attic Locations	Backer	Fastener	Sealant	Notes
Attic Top Plates	N/A	N/A	1- or 2-part foam, spray applied sealant	Platform construction.
Attic Top Plates	Fiber Glass	Friction Fit	2-part foam, spray applied sealant	
Attic Top Plates	XPS	Friction Fit	1- or 2-part foam or caulk, spray applied sealant	
Attic Top Plates	Foil Faced Wrap	1/2" staples	1- or 2-part foam, spray applied sealant or caulk	
Dropped Soffit	1/2 " drywall	1" drywall screws	1- or 2-part foam, spray applied sealant	Openings over spans larger than 24" must be supported.
Dropped Soffit	1.5" XPS	2"drywall screws	1- or 2-part foam, spray applied sealant	Openings over spans larger than 24" must be supported.
Dropped Soffit	1" FSK	1" drywall screws	1- or 2-part foam, spray applied sealant	Openings over spans larger than 24" must be supported.
Dropped Soffit	Foil Face Wrap	1/2 " staples	1- or 2-part foam, spray applied sealant	Openings over spans larger than 24" must be supported.
Junction Boxes	N/A	N/A	Silicone Caulk, spray applied sealant	No foam in electrical boxes.
Wire Penetration	N/A	N/A	1-part foam	
Kneewall transition	Fiber Glass	Friction Fit	2-part foam, spray applied sealant	Foam must create an air barrier.
Kneewall transition	XPS	Friction Fit	1-part foam, spray applied sealant or caulk	If exposed needs thermal barrier.
Kneewall transition	1' FSK	Friction Fit	1-part foam, spray applied sealant or caulk	Foam must create an air barrier.
Kneewall transition	Foil Face Wrap	1/2" staples	1-part foam, spray applied sealant or caulk	Foam must create an air barrier.
Chimney/Flue	Metal flashing	4d box nails or 1” drywall screws	High Temp Caulk	High temp sealant must be compatible with fuel type.
Chimney/Flue	Mineral Wool	Friction Fit	High Temp Caulk	If gaps are very small they can be stuffed and caulked.
Recessed Lights	Drywall/XPS	Tape	1-part foam or caulk	Drywall or XPS on the sides, drywall on top. Taped until foamed.
Open Chases	Drywall	1" drywall screws	1- or 2-part foam, spray applied sealant	Openings over spans larger than 24" must be supported.
Open Chases	1.5" XPS	2"drywall screws	1- or 2-part foam, spray applied sealant	Openings over spans larger than 24" must be supported.
Open Chases	1" FSK	1" drywall screws	1- or 2-part foam, spray applied sealant	Openings over spans larger than 24" must be supported.
Open Chases	Foil Faced Wrap	1/2" staples	1- or 2-part foam, spray applied sealant	Openings over spans larger than 24" must be supported.

Table 1. cont.

Attic Locations	Backer	Fastener	Sealant	Notes
Wet Wall Top Plates	XPS	Friction Fit	1- or 2-part foam, spray applied sealant or caulk	Backer must be moisture resistant.
Wet Wall Top Plates	1" FSK	Friction Fit	1- or 2-part foam, spray applied sealant or caulk	Backer must be moisture resistant.
Wet Wall Top Plates	Foil Faced Wrap	1/2" staples	1- or 2-part foam, spray applied sealant or caulk	Backer must be moisture resistant.

3.2.5 Attic Air Sealing Installation

This section defines what materials and methods are suitable when sealing penetrations between the attic and the conditioned space.

Attic Top Plates
Where exterior and interior walls terminate in the attic there is a junction between the wall board and the framing called the Attic Top Plate. This long, thin gap between the wall board and the wall framing, if left untreated, allows an unwanted exchange of conditioned house air and attic air. To seal this gap first remove any existing insulation or debris from either side of the top plate where it meets the wall board.

○*OPTIONAL BEST PRACTICE*○ Apply a continuous bead of 1-part urethane foam between the wooden top plate of the wall and the wallboard. 2-part foam or spray applied latex based sealants can also be used at this location.

When area applied sealants are used the entire top plate must be covered (i.e. only sheetrock and foam must be visible after the top plate has been sealed). **Photo**: Top Plates Sealed with 1-Part Foam

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Dropped Ceilings and Soffits
This attic detail most commonly occurs above bathrooms and kitchens. Wall board is often excluded from areas above cabinets, bathtubs and/or showers which results in open spaces that are open to wall cavities. These open spaces must be sealed from the attic using a rigid supported material that is installed and sealed in line with the attic plane. If the dropped soffit or ceiling is above a bathroom or kitchen a moisture resistant backer must be used. The span must be bridged by the backer leaving enough overlap at all edges to mechanically attach the backer to the surrounding attic air barrier. The edges and seams must be sealed with foam. **Photo**: Dropped Soffit Sealed with XPS and 1-Part Foam

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Junction Boxes and Wire Penetrations
Junction boxes may be sealed using siliconized or silicone caulk or equivalent. To ensure that the caulk bonds to the junction box, dust and debris must be brushed off. The openings in the box can be sealed with

the caulk but care must be taken not to inject the caulk into the junction box. Wire penetrations may be sealed with foam. The nozzle of the foam gun must be inserted into the wire hole and foam injected until the foam backs out into the attic space.

Open Joist Bays in Knee Wall Attics

This area, sometimes referred to as the knee wall transition, is the space where the floor joists of an unconditioned knee wall attic pass under the knee wall and transition from unconditioned space to what is typically conditioned space. If the kneewall attic is not included in within the pressure boundary, this transition must be sealed.

○*OPTIONAL BEST PRACTICE*○ To close this space, cut rigid foam board to the dimensions of the floor bays and rigid fit the foam board into the joist bay. The foam board must be inserted under the shoe plate of the knee walls inner (towards conditioned space) side. The inner face of the rigid board must align with the vertical plane of the wall board.

Any gaps or seams must be sealed. Silicone caulk or 1-part urethane foam are effective materials for this purpose. **Photo:** Knee Wall Transition Sealed with XPS and 1-Part Foam

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Whole House Fans

Whole house fan covers must be treated like attic stair case covers in regard to appropriate materials, installation techniques and code compliance. The fan itself must be dammed off from any blown material for a distance of two feet around the fan perimeter using batts laid flat, or other permanent barriers.

Chimney Flues & Vents

Closing the gap between heat sources and combustible materials requires the use of non-combustible materials. A clearance of three inches must be maintained between masonry chimneys or double wall metal vents and combustible materials, and six inches between single wall vents and combustible materials. The material used to seal this gap must be non-combustible air-tight material, such as metal flashing. The metal flashing must be applied over any openings that cannot be bridged by the sealants and mechanically fastened in place with nails, screws or staples. The flashing must be cut so that it spans the gap and leaves enough overlap to be attached with fasteners to surrounding framing, and so that when fastened in place the remaining gaps between the flashing and the venting and the flashing and the framing are ¼ inch or less and can be sealed with high temperature sealants (ASTM E136 for oil or wood flues, 500F RTV silicone for gas flues). Other sealants can be used on the side of the sheet metal that is fastened to the framing. **Photo:** Chimney in Attic Sealed with High-Temp Caulk and Metal Flashing

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Bath Fans

The housings of most bath fans have many perforations and knock-outs. In addition to the openings in the housing, it is not uncommon for there to be sizable openings between the housing and the attic plane material

(wall board, plaster, paneling, etc.). If the bath fan is a fan-light combination unit, it must be treated as a recessed light (see Section 3.3). If it does not have a light, the openings and perforations must be sealed with silicone caulk. The gap between the attic plane and the fan housing can be sealed with caulk if the gap is small enough or foam if the gap exceeds the maximum bead width of silicone caulk. **Photo:** Bath Fan Sealed with 1-Part Foam

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Open Chases

Material selection is the most critical aspect of sealing open attic chases. Backer materials that are used to seal chases must have sufficient rigidity to span the opening and support any insulation that will be placed upon it. Any span greater than 24 inches must be supported by framing members regardless of the material chosen. A moisture-resistant backer must be chosen when persistent exposure to moisture-laden air is deemed likely. Whatever material is chosen, it must be cut in a section large enough to span the chase and have enough overlap to be securely fastened to the surrounding framing. Any remaining gaps between the rigid material and the surrounding air barrier must be sealed with foam or caulk. Applicable fire codes apply for ignition barriers and thermal protection. **Photo:** Open Attic Chase Sealed with Sheet Metal, Duct Mastic and Acoustical Sealant

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Wet Walls and Plumbing Penetrations

A wet wall is a wall that has plumbing pipes running vertically through it to unconditioned space. These walls are often framed using higher dimension framing (i.e. 2x6's) or a double 2x4 stud wall. From the attic this wall is easy to locate. It is the one that the waste vent comes through. Usually, the top plate(s) of this wall have large openings that need to be bridged with a rigid, moisture resistant material and then sealed with foam. **Photo:** Plumbing Wet Wall Sealed with Fiberglass Batt Backer and 1-Part Foam

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Ceiling Height Level Changes

When ceilings change from one height to another a short wall is created with wall studs that run from the conditioned space into the unconditioned space of the attic. In the case of pre-platform framing, this transition area in the wall stud bay will normally not have an air barrier installed at all. If the house was built with platform framing, there may be a wood blocker with unsealed edges. If there is no backer in the wall stud bay at the transition from conditioned to unconditioned space, one must be installed. This backer can be rigid or spray foam insulation or a rolled insulation batt and sealed around the edges. **Photo:** Ceiling Height Transition Wall Sealed with 2-Part Foam

3.3 Recessed Lights

3.3.1 Definition

Recessed lights are a type of fixture that projects through the thermal boundary of a ceiling into the attic space or cathedral roof slope. The holes in the thermal boundary created by these fixtures are a source of air leakage and degrade the overall thermal performance of the insulation of the attic or cathedral roof plane. Depending on type, great care must be taken when sealing and insulating around recessed light fixtures.

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3.3.2 Requirements

Homes with recessed lighting fixtures that penetrate the thermal envelope should be air sealed and insulated using the following criteria and method:

1. First determine whether the fixture is a Non "Insulation Contact" (IC) rated fixture, an IC rated fixture, or an airtight IC rated fixture. If it is not possible to determine what type of fixture it is, then it must be treated as a Non-IC rated fixture.
2. If the fixture is Non-IC rated, or IC rated but not air tight, an air tight enclosure must be built from an air barrier material.

   ○*OPTIONAL BEST PRACTICE*○ Use a non-flammable material such as wall board, mineral fiber, or foil-faced fiberglass.

   The enclosure must be constructed securely to maintain a minimum clearance of 3 inches to any part of the fixture. Rigid foam insulation or other impermeable material can be used for the enclosure sides. However, the top of the enclosure must be made from a non-insulating material and must not exceed an R-value of .5. Insulation can be placed against the side of the enclosure but must NOT be placed over the top.
3. If the fixture is an air-tight IC rated can light fixture (ICAT) installation may be installed over it according to manufacturer specifications.

○*OPTIONAL BEST PRACTICE*○ Install an LED inset into a recessed light fixture and ensure that it is sealed around the perimeter with a sealant that is appropriate for close proximity to the LED light. This can eliminate air leakage while reducing lighting costs and may be easier to install than an enclosure in the attic above.

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3.4 Attic Access Air Sealing & Insulation

3.4.1 General

All attic accesses must be:

- As air tight as possible, using weather-stripping permanently mounted to the access and secured with metal fastenings that keep the access secure through repeated use.

  ○*OPTIONAL BEST PRACTICE*○ "Q-Lon" style weather-stripping products.

- Insulated to R-14 or greater, unless the construction of the attic (such as cross-bracing) impedes the ability to add sufficient insulation thickness. Foam boards, fiberglass, or rock wool batts are acceptable forms of insulation.

  ○*OPTIONAL BEST PRACTICE*○ Insulate access to the level of the remainder of the attic.

- Constructed from materials with a 20-year life span or greater

In the event that a contractor creates an access to the attic that must be permanently sealed (such as access through drywall, or situations where the contractor insulates the attic through a vent), the contractor must provide pre- and post-photos of the installed insulation and submit per Program Guidelines.

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3.4.2 Hatches

- The contractor must weather-strip and insulate the hatches but not permanently seal existing or installed hatches.
- All hatches must be weather-stripped on all four sides and the corners mitered to fit together. The seams between the weather-stripping and the finish, and in the finish, must be caulked with a siliconized caulk or equivalent. Any gap between the finish and the rough framing and the surrounding wall board must be sealed
- If necessary on pre-existing or installed hatches, positive closing mechanisms (such as eye hooks) must be installed on opposite sides with sufficient tension to ensure an effective seal.
- If necessary to prevent insulation spillage the attic hatch opening must be surrounded with a durable protective baffle that is higher than the level of the surrounding floor insulation.
- Installed hatches must be constructed of a minimum of ½ inch plywood, or material of comparable strength and acceptable to the homeowner.
- Installed hatches must be framed with a minimum 2½ inch casing permanently fixed with metal fastenings, mitered neatly, weather-stripped, and insulated to a level consistent with the attic area around it.

○*OPTIONAL BEST PRACTICE*○ Insulate attic hatch with foam board. The first layer of foam board can be attached using screws and 1 inch or wider washers spaced approximately every 8 inches. Additional layers must be added by gluing to the lower layer using construction adhesive. If using Extruded Polystyrene (XPS) do not apply a petroleum-based adhesive on the XPS.

. **Photo:** Attic Hatch Weather-stripped

3.4.3 Temporary Access through a Wall or Ceiling

Where entry to the attic via a pre-existing hatchway of access panel is not possible, access to attic areas may be gained from the exterior through roof or gable vent openings. If this is not feasible, access may be created by cutting through the ceiling between two ceiling joists or the knee wall area between two wall studs.

- Openings must be cut in such a manner as to ensure structural integrity of the dwelling.

  ○*OPTIONAL BEST PRACTICE*○ Use a stud finder to identify the location of wall studs or ceiling joists, then cut an opening between them, being careful to ensure that no electric wiring is damaged.

- If no permanent access is intended, the opening must be closed with the same or comparable material that is flush with the existing ceiling or wall material. At least one coat of joint compound must be applied, smooth enough to allow the application of a second coat of compound, resulting in a smooth surface that will have minimal visibility when painted. If Program incentives or Program loans are applied to this measure, signed authorization from the homeowner must be obtained, and provided to Program staff upon request.

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3.4.4 Pull-down Staircase Enclosures

Pull-down Staircase enclosures must consist of an air tight enclosure that fits over the top of the stairs. This may be constructed on site or purchased as a kit.

- The enclosure must have a minimum R-value of 14.
- This enclosure must be large enough to allow the pull-down staircase to close without interference.
- The cover must be cut to lengths that fully encompass the framing surrounding the staircase. The side must be of sufficient height to accept the folding stairs without being disturbed.
- All seams of this enclosure must be sealed with construction glue, foil tape or other material that ensures a tight, durable, permanent seal.
- The existing surrounding framing of the attic deck must be complete and level enough to allow weather-stripping on the bottom of the enclosure or attached to the deck to engage all the way around the enclosure. There must be some type of fastening mechanism (eye hooks, Velcro, brackets, etc.) with sufficient tension to engage the weather-stripping on all four sides. This box must be constructed of materials light enough to be easily moved aside by the homeowner.
- If the attic space may be used for storage or any purpose other than repairs or maintenance, any foam board that is included on the enclosure must have a thermal barrier. **Photo:** Pull-down Stair Cover

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3.4.5 Attic Doors (including Kneewall access doors)

- Attic doors must be weather-stripped using Q-lon style weather-stripping or equivalent.
- The seam between the framing or finish and the weather-stripping must be sealed with a bead of caulk.
- The door must be swept with a non-spring-loaded door sweep.
- Insulation, such as rigid foam board insulation, with an R-value of 14 or greater, must be permanently fastened to the back side of the door with metal fastenings. If the foam board insulation is not rated for exposure, a thermal barrier must be installed.

○*OPTIONAL BEST PRACTICE*○ Attach with screws and 1-inch washers spaced approximately 8 inches apart.

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3.5 Wall Air Sealing

3.5.1 General

The following are general requirements for wall air sealing:

1. Sealant materials must be compatible with the wall assembly materials and must allow normal movement due to changes in temperature and humidity and air pressure variations.
2. Sealant materials must be in a matching color to the substrate or be paintable.
3. Sealants must be installed in a manner that continues the function of the drainage plane. Do not install sealants in a manner that will hold water in the wall assembly.
4. When insulation is used as part of the air barrier system, the installation must be an air tight material or meet the minimum density for the material. (See: “Dense Pack Insulation” in Section 3.14.3: Wall Insulation/Installation).
5. When membranes or films are used as air barrier system components, the entire perimeter of the material must be air sealed.
6. Windows, doors, and skylights must be integrated into the wall air barrier system. Seal the portion of the window, door, or skylight that is the air barrier component of the opening assembly to the air barrier component of the wall assembly, not the exterior siding or trim.
7. Mechanical penetrations must be sealed to the air barrier component of the wall assembly, not the exterior siding or trim.

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3.5.2 Material

Wall air sealing materials can be broken into three different materials: Backers, Sealants, and Dense Pack Insulation.

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Backers

Backers are materials used to bridge openings that cannot be closed by sealants. Following is the list of appropriate backers for use when air sealing walls.

1. Fireproof Backers:
    a. Metal Flashing
    b. Mineral Wool
2. Fire-resistant Backers:
    a. Wall Board
3. Moisture-permeable Backers:
    a. Wall Board (unpainted)
    b. Building Wrap
4. Other Backers:
    a. 6-mil Polyethylene
    b. Radiant Bubble Wrap
    c. Plywood/OSB
    d. Thermo-Ply
    e. Structural insulated sheathing
    f. Foam Backer Rod

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Sealants

Sealants are any material applied to the existing wall air barrier or the installed backer that forms an air tight seal. Following is a list of appropriate sealants for use when air sealing walls.

1. Fireproof Sealants:
    a. Non-combustible fire rated caulk meeting ASTM E 136
    b. Silicone high temp RTV on gas vents to 500 degrees Fahrenheit meeting ASTM C920
2. Non-Fireproof Sealants:
    a. 1-part urethane foam
    b. 1-part urethane fire block foam rated for sealing gaps in wood framing
    c. 2-part urethane foam kits
    d. Siliconized latex sealants meeting ASTM C834
    e. Silicone urethane and other elastomeric sealants meeting ASTM C920
    f. Spray applied latex based sealant

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Wall Insulation as an air sealing strategy

Fibrous insulations blown into an enclosed cavity at a specified density can greatly reduce air flow through the cavity and can be considered a form of air sealing. The two most widely used materials for this application are cellulose and glass wool (fiber glass). Foam insulation injected into walls may also serve as an air sealing strategy.

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Table 2. Compatible Wall Air Sealing Materials

(Note: This table lists effective combinations of backers, fasteners, and blockers. Other combinations are possible.)

Wall Locations	Backer	Fastener	Sealant	Notes
Wall Cavities	N/A	N/A	Cellulose	Dense pack cellulose to 3.5+ lbs/cuft.
Wall Cavities	N/A	N/A	Fiber Glass	Dense pack fiber glass to 2.2+ lbs/cuft.
Wall Cavities	N/A	N/A	Spray Foam	See Appendices B,C,D for installation specifications.
Heat Sources	Metal Flashing	4d box nails	High Temp Caulk	Use compatible caulk and fuel combination.
Moisture Resistant Interior	Drywall/Paint (two layers of latex)	1" drywall screws	see notes	if finished look use joint compound, if not use 1-part foam or spray applied sealant.
Moisture Resistant Interior	1.5" XPS	2" drywall screws	1-part foam, spray applied sealant or caulk	Not for finished areas.
Moisture Resistant Interior	6 mil polyethylene	1/2" staples	1-part foam, spray applied sealant or caulk	Not for finished areas. "Tu-Tuff" or similar thinner sheeting may be substituted.
Moisture Resistant Interior	foil faced wrap	1/2" staples	1-part foam, spray applied sealant or caulk	Not for finished areas.
Moisture Resistant Exterior	Metal Flashing	4d box nails	silicone caulk	
Moisture Resistant Exterior	Building Wrap	1/2" staples	Sheathing Tape	Sealant must be protected from exterior exposure immediately.
Moisture Resistant Exterior	Rigid Insulation	Screws	Sheathing Tape	Sealant must be protected from exterior exposure immediately.
Moisture Resistant Exterior	polyethylene	1/2" staples	Sheathing Tape	Sealant must be protected from exterior exposure immediately.
Other Openings	1/2" drywall	1" drywall screws	see notes	Finished look use joint compound, if not use 1-part foam. 1st choice-finish & fire rating.

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3.5.3 Installation of Wall Air Sealing

Air sealing the exterior walls can be broken into distinct parts. There is the combination of air sealing and insulation embodied in dense packing. There are heat sources that must be dealt with using fire proof materials and methods. There are seals made in areas that must resist moisture intrusion or allow vapor to

escape when necessary. Finally, there are just penetrations through the walls that can be dealt with using "other" backers and non-specialized sealants.

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Heat Sources

Any penetrations through exterior walls that are considered a heat source (stove pipes, etc.) must be sealed using fireproof materials. If the gap between the existing wall air barrier and the venting system cannot be bridged by sealants alone, the gap may be bridged with metal flashing and sealed with furnace cement meeting ASTM E136. An alternative method is to stuff the gap with mineral wool as a backer (and insulation) and seal the mineral wool with a fire-rated furnace cement meeting ASTM E136. If the gap is small enough to bridge with sealant alone it must be sealed with a fire-rated furnace cement meeting ASTM E136.

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Moisture Resistant Seals

Air sealing of exterior walls in some locations may require the use of a material that is a class I vapor retarder. Such locations could be bathrooms, kitchens or other areas of high moisture concentration. When sealing out moisture is a consideration and the opening in the air barrier is too large to close with sealant, the opening must be sealed with one of the following:

1. For interior sealing that is meant to retard vapor diffusion, XPS, wallboard painted with two layers of latex paint, and polyethylene are appropriate materials. Appropriate interior sealants are siliconized latex sealants meeting ASTM C384, silicone caulk meeting ASTM C920, 1-part urethane foam, and duct mastic.
2. For exterior sealing meant to stop bulk moisture intrusion metal flashing, building wrap, polyethylene, and XPS are appropriate materials. Once the backer is selected based on location, suitability, and appearance a compatible sealant must be matched to the location and finished appearance. Suitable exterior sealants include siliconized latex sealants meeting ASTM C384 or silicone caulk meeting ASTM C920.

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Other Wall Penetrations

When sealing interior wall penetrations that are not heat sources or areas of high moisture concentrations the choice of backer on large openings must be chosen based on two criteria: compatibility with the surrounding finish, and fire resistance. Where visible or exposed to the living space, wallboard is an optimum material of choice as a backer due to its classification as a thermal barrier and its ability to be finished easily. Sealants in visible areas must be limited to either low sheen clear caulks or paintable caulks where applicable. 1-part foam can be used if it will then be covered by insulation or some form of thermal barrier. (See Appendix B, Section B.5: Fire Protection)

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Seal Baseboards
If a room is not carpeted, the baseboard can be sealed by caulking the seam between the baseboard molding and the floor and the baseboard molding and the drywall.
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Window and Door Trim Sealed
The trim around windows and doors can be sealed using caulk at the seam between the window trim and the window frame and the seam between the window trim and the drywall.

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Plumbing Penetrations Sealed
The area where plumbing pipes pass through walls can be sealed with caulk if the gap is less than ¼ inch, 1-part foam if the gap is less than 1 inch, or 1-part foam or caulk, with a backer, if the gap is greater than 1 inch.

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HVAC Boot to Subfloor/Drywall Sealed
The area where a Heating, Ventilation and Air Conditioning (HVAC) supply or return boot penetrates the subfloor or drywall on a wall or ceiling can be sealed with duct mastic or caulk if the gap is less than ¼ inch. If the gap is greater than ¼ inch a backer must be used and then sealed with mastic.
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Interior Sheathing Voids Repaired
Holes and gaps in the interior sheathing must be repaired with a material similar to the surrounding materials. These repairs must be discussed with the homeowner prior to beginning the repair to get approval of material and sealing methods.

○*OPTIONAL BEST PRACTICE*○ Create a signed agreement with the homeowner that details the expectation of the condition of the area after completion of work by the contractor. Take photos upon completion of the work.
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3.6 Conditioned Basement Air Sealing

3.6.1 General

Basements are spaces that are primarily below grade. Basements are considered to be conditioned spaces in this section of the MIG. See: Crawlspace & Unconditioned Basement Air Sealing for sealing recommendations in those areas.

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3.6.2 Heat Sources

The following penetrations from the basement to the exterior or the basement to the conditioned space are considered heat sources: Flue pipes from heating or Domestic Hot Water (DHW) systems; flue pipes from solid fuel burning appliances.

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3.6.3 Locations and Use

The following basement locations should be considered for air sealing, depending on the location of the dwelling's pressure plane, and pollutants in the space. Care must be taken to ensure that a path remains to provide adequate combustion air for any HVAC equipment or woodstoves in the basement.

1. Mechanical Chases and Other Large Openings
2. Rim Joists & Sills
3. Water Pipes
4. Leaky Basement Windows
5. Dryer Vents
6. Plumbing Penetrations
7. Small openings between the basement and conditioned or exterior spaces

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3.6.4 Materials

Basement air sealing materials have different recommendations based on the potential for high relative humidity in the space. Organic materials that support mold growth or materials that lose their rigidity after absorbing moisture must not be used. In addition to these recommendations, rigid foam board insulation that is used in a finished basement must either be fire-resistant or have a thermal barrier. Foam installed in basements or crawlspaces that can be used for storage or accessed for any other purpose beyond repair and maintenance of HVAC equipment must have a thermal barrier. A thermal barrier is not required for the installation of foam on a sill plate/rim joist area, provided that the maximum thickness of the foam is 3 ¼ inches (See Appendix B, Section B.5: Fire Protection). State and local codes must be checked for additional fire barrier recommendations and requirements.

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Backers

Materials that *do not* need a thermal barrier:

1. Thermax rigid foam board
2. Metal Flashing
3. Mineral Wool
4. Polyethylene
5. Foil Bubble Wrap

Materials that *may* need a thermal barrier:

1. Rigid Foam Board (except Thermax)
2. Spray applied foam plastic insulation

Sealants

Materials that *do not* need a thermal barrier:

1. 1-part foam
2. Siliconized latex sealants meeting ASTM C834
3. Silicone urethane sealants meeting ASTM C920
4. Water based duct mastic meeting UL181A, UL181B-M
5. Spray applied latex based sealants

Materials that *do* need a thermal barrier:

1. 2-part foam used as a sealant in a finished basement space, or a basement that can be used for storage, must have a thermal barrier (See Appendix B, Section B.5: Fire Protection).

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3.6.5 Installation

The following installation instructions for basement air sealing locations details the most common appropriate materials and practices.

Heat Sources

If the gap around heat sources is too great for sealant alone, the gap must be closed with non-combustible material, such as metal flashing mechanically fastened to surrounding framing. If the appliance burns solid fuel or oil, the edges and gaps must be sealed using fire-rated caulk meeting ASTM E136. If the appliance burns natural gas or propane, the edges and seams must be sealed with high temperature silicone RTV meeting ASTM C920. **Photo:** Chimney in Basement Sealed with Sheet Metal and High-Temp Caulk

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Mechanical Chases and Other Large Openings

Large openings between the basement and the conditioned space or the exterior must be backed with a fire-resistant material that does not support mold growth. For this reason, materials such as wall board or other paper-based products are not suitable. Further, if the opening is between the basement and the conditioned space, then the material must also be a class 1 vapor retarder. Appropriate materials for closing large gaps include Thermax, mineral wool, metal flashing or polyethylene. Materials such as XPS or other foil faced foam boards are appropriate if they will be either covered with insulation after installation or treated with a thermal barrier. The rigid material must be cut to fit over the opening with at least an inch of overlap where possible. The backer material must be fastened into place with mechanical fasteners (screws, staples etc.). Once the backer is secured firmly into place, the edges must be sealed using caulk or 1-part foam.

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Rim Joists & Sills

In situations where the basement or crawlspace has been defined as being within the building envelope, and rim joists are selected as an air sealing measure, rim joists must be sealed in such a manner as to eliminate air leakage from outside of the building envelope.

○*OPTIONAL BEST PRACTICE*○ Insulate the rim joist area as well as air sealing it. Acceptable methods for sealing rim joists include the following:

1. Seal with 2-part foam. In this application the foam can be extended from the subfloor to the junction of the foundation and the sill plate. In areas where termite infestations may exist, code may require an inspection break between the foam and the bottom of the sill. If there is a termite inspection break, the seam between the foundation and the bottom of the sill must be sealed using silicone caulk. This approach provides an insulation value.
2. Seal by cutting blocks of rigid foam board to fit in the rim joist area and sealing the edges with caulk or 1-part foam. In this application the sill-to-foundation seam and the seam between the two sill plates must also be caulked. This approach provides an insulation value. **Photo:** Rim Joist Sealed to Sill (and Insulated) with Foam Board and 1-Part Foam.
3. Seal all gaps in the rim joist area with caulk or foam. This application does not by itself provide an insulation value. If insulation is subsequently added to the rim joist area, care must be taken to ensure that moisture is prevented from migrating through the insulation to the rim joist, where it may reach the dew point and cause damage.

Note: A thermal or ignition barrier is not required for the installation of foam on a sill plate/rim joist area, provided that the maximum thickness of the foam is 3 ¼ inches, and the foam does not extend down the vertical wall below the sill plate.

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Water Pipes

Air infiltration into basements is the main cause of pipes freezing. It must be noted that in some dwellings water pipes as far as five feet from the rim joist area can be frozen when temperatures are low enough and the air is driven into the space by high winds. The basement must be thoroughly inspected for water pipes that could be frozen by wind-driven air infiltration. In these spaces, where pipes are at risk, the perimeter of the basement can be sealed in such a manner as to reduce the risk of freezing pipes. Methods for sealing the perimeter can be found in “Rim Joists & Sills”, above.

Basement Windows

Gaps in the frame and joints between the frame and the surrounding air barrier that are smaller than ¼ inch must be sealed with caulk. Larger gaps must be backed by backer rod and the seams caulked.

Dryer Vents

In situations where a pre-existing dryer vent is found or suspected to be combustible, the contractor must ensure that foam or other combustible insulation is not installed in direct contact with the combustible section of the dryer vent. This may be done by either:

1. Replacing the dryer vent with a non-combustible, code-compliant dryer vent, or
2. Treating the dryer vent as a heat source and protecting the dryer vent from contact with combustible insulation. If the gap between the dryer vent and the building surface is less than ¼ inch it can be sealed with high temperature silicone for gas vents meeting ASTM C920. If there is a gap too wide to be bridged by sealant alone, the gap must be sealed using either metal flashing or mineral wool. The edges and seams must then be sealed with high temperature silicone for gas vents meeting ASTM C920.

Plumbing Penetrations

If the gap between the pipe wall and the subfloor is less than ¼ inch the gap may be sealed using caulk. If the gap is between ¼ inch and 1 inch it can be sealed using 1-part foam. If the gap is greater than 1 inch it must be bridged using a moisture-resistant, fire-resistant material. Foam board, metal flashing, OSB, or plywood are appropriate materials for this application. (Foam board must either be rated for exposure (i.e. Thermax) or be covered with a thermal barrier.) Once the gap is closed, the edges and seams must be sealed with either caulk or 1-part foam.

Small Openings Between the Basement and Conditioned or Exterior Spaces

Small openings must be sealed using a fire-rated sealant. This can be a 1-part foam product or a fire-rated caulk.

3.7 Crawlspace & Unconditioned Basement Air Sealing

3.7.1 General

Crawl spaces use the same guidelines as Basements above, with the following additional considerations:

1. Code compliance: When working in crawl spaces all applicable national, state, and local codes regarding vapor retarders, ventilation, and thermal barriers (based on use type) in crawl spaces must be followed.
2. Access considerations: When specifying energy upgrades in a crawl space auditors must keep access restrictions and ease of installation in mind when specifying methods and materials.
3. Use the appropriate safety measures when crawl spaces qualify as confined spaces.

Table 3. Compatible Crawlspace & Unconditioned Basement Air Sealing Materials

(Note: This table lists effective combinations of backers, fasteners, and blockers.. Other combinations are possible)

Crawlspace & Basement Locations	Backer	Fastener	Sealant	Notes
Heat Sources	Metal Flashing	4d Box nails	High Temp Sealant	Use compatible sealant and fuel combination.
Heat Sources	Mineral Wool	Friction Fit	High Temp Sealant	If gaps are 1/4" or less stuff and seal.
Mechanical Chases	1" Thermax	2" drywall screws	1 or 2-part foam, spray applied sealant or caulk	Use Thermax, not any other type of rigid foil faced board. Exposed foam plastic insulation must have a fire barrier.
Mechanical Chases	Metal Flashing	4d box nails	1 or 2-part foam, spray applied sealant or caulk	Exposed foam plastic insulation must have a fire barrier.
Mechanical Chases	Polyethylene	1/2" staples	1 or 2-part foam, spray applied sealant or caulk	Exposed foam plastic insulation must have a fire barrier.
Mechanical Chases	1 or 1.5" XPS	2" drywall screws	1 or 2-part foam or caulk	Must have a thermal barrier if not covered by insulation.
Mechanical Chases	Rigid Insulations	2" drywall screws	1 or 2-part foam, spray applied sealant or caulk	Any rigid board insulation other than Thermax must have a thermal barrier if exposed.
Mechanical Chases	1" FSK	2" drywall screws	1 or 2-part foam, spray applied sealant or caulk	Exposed foam plastic insulation must have a fire barrier.
Mechanical Chases	Foil Face Wrap	1/2" staples	1 or 2-part foam, spray applied sealant or caulk	Exposed foam plastic insulation must have a fire barrier.
Large Openings				See Mech Chases.
Rim and Band	N/A	N/A	Spray Foam, spray applied sealant	In unconditioned basements or crawl spaces 2-part spray foam does not require a fire barrier.
Rim and Band	Rigid Insulations	Friction Fit	1-part foam, spray applied sealant or caulk	Rigid insulation must be rated for exposure or treated with a fire barrier
Rim and Band	N/A	N/A	1-part foam, spray applied sealant or caulk	The framing junctions can be caulked or foamed and batt insulation added.
Pipe Penetration	Fiber Glass	Friction Fit	1-part foam or spray applied sealant	for gaps greater than 1"
Pipe Penetration	Foil Face Wrap	1/2" staples	1-part foam, spray applied sealant or caulk	for gaps greater than 1"

(Table 3 Cont.)

Crawlspace & Basement Locations	Backer	Fastener	Sealant	Notes
Pipe Penetration	N/A	N/A	1-part foam, spray applied sealant	for gaps between 1/4" and 1".
Pipe Penetration	N/A	N/A	caulk	for gaps 1/4" or less
Windows/Doors	Backer Rod	Friction Fit	caulk	for gaps more than 1/4"
Windows/Doors	N/A	N/A	caulk	for gaps less than 1/4"
Windows/Doors	N/A	N/A	1-part foam or spray applied sealant	gaps between 1/4" and 1". Care must be taken during installation to avoid over filling
Dryer Vent				See Heat Sources

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3.8 Kneewall Attic Air Sealing

3.8.1 General

Roof vs. Wall & Floor

In determining options for air sealing in a knee wall area, it is important to first make a determination as to whether the knee wall attic is inside or outside of the pressure boundary of the dwelling.

- Inside (conditioned space): Air sealing follows the line of the roof rafters, which will bring the knee wall attic space inside the conditioned area.
- Outside (unconditioned space): Air sealing follows the knee wall itself from the sloped ceiling to the attic floor and then across the knee wall attic floor to the exterior wall top plate.

Vapor Permeable Air Barrier on Knee-walls

If the knee wall attic is air sealed as unconditioned attic space, this space must be ventilated according to state and local codes. Ventilating this space will make the knee wall insulation susceptible to wind washing. Therefore, a vapor permeable air barrier must be added to protect the installed insulation from wind washing. Dense pack insulation installed with webbing is an acceptable method of reducing the impact of wind washing.

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3.8.2 Locations and Use

Knee wall or other side-attic areas, including rim joist areas under single-story shed roof, gambrel, garage, or other floor framing very often open into vented or unconditioned attic areas. If some areas are inaccessible, strategic dense-pack insulation must be considered to slow or stop leakage.

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3.8.3 Material

If the attic has been sealed along the knee wall, and the attic floor and has been pushed outside of the conditioned space, refer to Section 3.2.4: Attic Air Sealing/ Material.

Air Barrier Aligns with Roof Rafters

This plane must be sealed with an air impermeable barrier. If the rafter bays are insulated with glass fiber or cellulose insulation, the following air barriers are appropriate:

1. Wallboard
2. Foam board (Must either be rated for exposure (i.e. Thermax) or be covered with a thermal barrier).
3. Plywood
4. OSB
5. Structural insulated sheathing
6. Polyethylene
7. Building wrap

If the rafter bays are insulated with spray foam the air barrier must be a thermal barrier also. Appropriate materials in this situation would be:

1. Wallboard
2. Foam board (Must either be rated for exposure (i.e. Thermax) or be covered with a thermal barrier.)

Air Barrier Aligns with Knee Wall and Attic Floor

If the air barrier aligns with the attic knee wall, the interior face of the knee wall will be the air barrier. The material used to seal the knee wall transition area will depend on access.

If the knee wall attic floor is not decked, the following materials are appropriate for sealing the opening between the floor joist cavities:

1. Rigid foam board
2. Wallboard
3. Framing lumber
4. Structural insulated sheathing
5. Foil-faced bubble wrap

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3.8.4 Installation

Air Barrier Aligns with Roof Rafters

If the air barrier is going to align with the roof rafters and bring the knee wall attic inside the conditioned space, an air barrier material must be run from the top plate of the knee wall to the top plate of the exterior wall. This air barrier can be a rigid material like Thermax, XPS with a thermal barrier, or wall board, or it could be polyethylene or building wrap. The air barrier must be mechanically fastened with screws for rigid materials or staples for flexible barriers. All seams and edges must be sealed. Acceptable applications include 1-part foam on rigid materials, 3M 8086 or equivalent tape on polyethylene or building wrap tape on building wrap. **Photo:** Knee wall Attic Air Sealed Along Rafter Line (attic space within thermal/pressure boundary).

Air Barrier Aligns with Knee Wall & Attic Floor

If the air barrier aligns with the attic knee wall, the interior face of the knee wall will be the air barrier. The seam where the shoe plate of the knee wall sits on the subfloor must be sealed with caulk. If the knee wall attic floor is not decked, a solid substance that blocks the opening, such as rigid foam board, must be used to seal beneath the knee wall area.

If the attic knee wall floor is sheathed this area must be air sealed using dense pack insulation, or by removal of the sheathing and treatment of the area below the kneewall as noted above

○*OPTIONAL BEST PRACTICE*○ Foam board can be cut into sections and rigid fit under the interior edge of the shoe plate so that it aligns with the interior face of the knee wall. The seams between the foam board and the floor joists, ceiling, and subfloor must be sealed with 1-part foam or caulk. The foam board must be covered with fire protection if the kneewall attic will be used for storage.

○*OPTIONAL BEST PRACTICE*○ In some cases it may be desirable to stop blown-in material from penetrating too far down a bay above the living space when dense packing. In this case a burlap "feedbag" may be used as an inflatable insert into the floor joist bay. This can be done by stuffing the bag through the drill hole while holding onto the opening of the feed bag. The fill tube can then be inserted into the feed bag and the feedbag "inflated" with blown in material until it fills the bay and forms a plug under the knee wall. The remainder of the bay can then be dense packed without fear of insulation entering areas where it is not intended. The top plate of the exterior wall and any penetrations through the attic knee wall floor must be treated as specified in Section 3.2.5: Attic Air Sealing Installation.

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Photo: Knee wall Attic Diagram for Air Sealing Along Wall/Floor Framing (attic space outside thermal/pressure boundary).

Table 4. Compatible Kneewall Attic Air Sealing Materials

(Note: This table lists effective combinations of backers, fasteners, and blockers. Other combinations are possible.)

Kneewall Attic Locations	Backer	Fastener	Sealant	Notes
Conditioned Kneewall	1/2" drywall	1" drywall screws	1-part foam, spray applied sealant or caulk	Qualifies as a thermal barrier if used over foam insulation.
Conditioned Kneewall	1" Thermax	2" drywall screws	1-part foam, spray applied sealant or caulk	Qualifies as a thermal barrier if used over foam insulation.
Conditioned Kneewall	1/2" Plywood/OSB	1" drywall screws	1-part foam, spray applied sealant or caulk	Qualifies as a thermal barrier if used over foam insulation.
Conditioned Kneewall	Structural Sheathing	1" drywall screws	1-part foam, spray applied sealant or caulk	Qualifies as a thermal barrier if used over foam insulation.
Conditioned Kneewall	Polyethylene	1/2" staples	Sheathing Tape	Does not qualify as an ignition barrier
Conditioned Kneewall	Building Wrap	1/2" staples	Sheathing Tape	Does not qualify as an ignition barrier
Unconditioned Kneewall				The interior face of kneewall will be the air barrier. See "attic knee wall transition" for materials to be used in that area. Seal holes in kneewall to conditioned space using Wall Air Sealing table 2.2.7.4.

3.9 Floors Over Unconditioned Space or Ambient Conditions Air Sealing

3.9.1 Overhang Air Sealing

General

Overhangs are a type of floor over unconditioned space, usually outside. Because of its exposure to the exterior it is necessary that the insulation be protected from the weather as well as from air movement.

Access Considerations

Access to the overhang will determine the method used to seal the floor joist bay transition area. If access cannot be gained to seal by other means, dense pack may be used to slow air flow through this area.

Confined spaces

Use special safety measures when crawl spaces qualify as confined spaces.

Material

The following materials are appropriate for use in the following overhang configurations:

1. Backers:

- Foam board (Must either be rated for exposure (i.e. Thermax) or be covered with a thermal barrier.)
- Rolled batt
- Foil-faced bubble wrap
- Structural Insulated sheathing
- Framing lumber
- Wallboard

2. Sealants:
    - 1-part foam
    - 2-part foam
    - Silicone caulk
    - Duct mastic
    - Spray applied latex based sealants (must not be exposed to sun or weather) can be used wherever 1-part or 2-part foam are used as sealants.

Installation

Methods and materials for sealing overhangs will depend on existing conditions and access. For all overhangs in cold climates the floor joist bays must be inspected to ensure that water pipes running through these areas will end up inside the conditioned area. Generally, this means that 75% of the insulation to be installed will be on the exterior side of the water pipes. If floor bays have ducts installed in them, then the ducts must be made air tight before pushing them outside with air sealing, especially before dense packing the joist bay. The following configurations must be sealed as specified here:

Overhang Accessible from Interior Space**:** Before sealing the transition area, the floor bay must be filled with insulation. The area where the floor joist crosses over the sill plate or exterior wall top plate must be sealed with an appropriate backer and the seams on all four sides of the backer sealed with 1-part foam or siliconized caulk. On the exterior, the seam between the sheathing on the bottom surface of the floor joist and the surrounding siding/sheathing must be sealed using a silicone caulk rated for exterior use.

Exterior Overhang with Sheathing**:** Removed **for** Access **or** No Sheathing**:** Seal the transition area using an appropriate backer. Seal the seams around the backer using 1-part foam, silicone caulk or equivalent.

○*OPTIONAL BEST PRACTICE*○ Fill the overhang floor bays with insulation, if there is enough clearance at the bottom of the floor joist and the bottom of the siding/sheathing consider adding a layer of rigid foam board to break the thermal bridge before replacing or installing the overhang sheathing. Seal the overhang sheathing to the surrounding siding or sheathing using silicone caulk.

No Access to the Overhang Floor Bays

This area can be dense packed to slow air flow. A thorough inspection of the floor joist bays must be made to ensure that there are no water pipes, ducts or recessed fixtures in the area to be dense packed. To stop the

unwanted flow of blown insulation down the floor bays and into the conditioned space, the burlap "feedbag" method can be used. See Section 3.8.4/Air Barrier Aligns with Knee Wall & Attic Floor

The seam between the overhang sheathing and the exterior sheathing or siding must be sealed using silicone caulk.

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3.9.2 Air Sealing Garage walls adjacent to conditioned spaces; frame floors over garage

Material

The following materials are appropriate for use in frame floor configurations when sealing the ends of bays exposed to outside air movement or large openings between the garage and conditioned space:

1. Backers:
   a. Foam board (Must either be rated for exposure (i.e. Thermax) or be covered with a thermal barrier)
   b. Rolled batt
   c. Foil-faced bubble wrap
   d. Structural Insulated sheathing
   e. Framing lumber
   f. Wallboard
2. Sealants:
   a. 1-part foam
   b. 2-part foam (with thermal barrier, unless at rim and band joist area)
   c. Silicone caulk
   d. Duct mastic
   e. Spray applied latex based sealants (must not be exposed to sun or weather) can be used wherever 1-part or 2-part foam are used as sealants.

Installation

Methods and materials for sealing areas adjacent to garages will depend on existing conditions and access.

1. **For all frame floors** the floor joist bays must be inspected to ensure that water pipes running through these areas will end up inside the conditioned area. Generally, this means that 75% of the insulation to be installed will be on the exterior side of the water pipes.
2. **Ducts running along and below a garage ceiling**, or along a garage wall must be made air tight.

   ○*OPTIONAL BEST PRACTICE*○ Insulate the ducts after air sealing.

3. If **floor bays above a garage ceiling have ducts running through them**, the ducts must be made air tight whenever practical. Note: cavities with flex duct should NOT be dense-packed, as the insulation is likely to compress and compromise the effectiveness of the duct. Alternative methods, such as inserting batt insulation around the flex duct, should be considered.

4. **If a heat source such as a flue pipe from a heating system located in area to be dense packed**: This heat source located in an enclosed space must have the bay that it is located in blocked with an appropriate backer with a clearance of at least three inches between the dam and the heat source. The backer must be made air tight with the surrounding materials to remove the chance that the insulation dust, under pressure could be forced within three inches of the heat source. If the heat source is close to one side of the bay and blown material in an adjacent bay is within three inches of the heat source, the adjacent bay must have a non-combustible insulation type (i.e. mineral wool) installed anywhere in that bay that is within three inches of the heat source.
5. **If a flue pipe from a heating system traverses the pressure boundary**, and the gap around the heat source is too great for sealant alone, the gap must be closed with metal flashing mechanically fastened to surrounding framing. If the appliance burns solid fuel or oil, the edges and gaps must be sealed using fire-rated caulk meeting ASTM E136. If the appliance burns natural gas or propane, the edges and seams must be sealed with high temperature silicone RTV meeting ASTM C920.
6. **Large openings between the garage and the conditioned space** must be backed with a fire-resistant material. Appropriate materials for closing large gaps would be Thermax, plywood or Oriented Strand Board (OSB), drywall or structural insulated sheathing. Materials such as XPS or other foil faced foam boards are appropriate if they will be either covered with insulation after installation or treated with a thermal barrier. The rigid material must be cut to fit over the opening with at least an inch of overlap where possible. The backer material must be fastened into place with mechanical fasteners (screws, staples etc.). Once the backer is secured firmly into place, the edges must be sealed using caulk or 1-part foam.
7. **Plumbing Penetrations:** If the gap between the pipe wall and the subfloor is less than ¼ inch the gap may be sealed using caulk. If the gap is between ¼ inch and 1 inch it can be sealed using 1-part foam. If the gap is greater than 1 inch it must be bridged using an appropriate backer. Foam board, metal flashing, OSB, or plywood or other appropriate materials for this application. (Foam board must either be rated for exposure (i.e. Thermax) or be covered with a thermal barrier.) Once the gap is closed, the edges and seams must be sealed with either caulk or 1-part foam.
8. **Small openings between the garage and conditioned space** must be sealed with a fire-rated sealant.
9. **Rim Joists and Sills** must be sealed as per Section 3.6.5 – Rim Joists and Sills, above

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3.10 Window Weather-stripping

3.10.1 General

Technicians are not required to weather-strip windows and doors as part of air sealing, but they may, based on customer comfort issues or where large leaks are found. Weather-stripping is recommended for doors between living space and garage.

In addition to weather-stripping of doors and windows it may sometimes be necessary to install window sash locks, eye hooks, barrel bolts, etc. to make the installed weather stripping engage effectively.

○*OPTIONAL BEST PRACTICE*○ Educate the customer on the value of ensuring that all storm windows are adjusted seasonally, and that employing window locks may (depending on design) improve air sealing effectiveness.

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3.10.2 Locations and Use

Window weather-stripping must only be installed where it does not have the potential to interfere with the smooth operation of the window and where normal operation of the window will not cause the weather-stripping to be torn out.

Window Weight Treatment

There are two separate window weight treatment techniques. Which technique is chosen is based on what treatment the window is undergoing. If the window is being weather-stripped only, then pulley seals can be installed to slow air leakage through the pulley openings. If the window is being replaced, the window weight cavities must be accessed through the lower sash channel access panel. The ropes or chains that the weights hang on must be cut and removed along with the weights themselves. The pulleys must be removed from the upper sash channels and the opening covered with duct tape. The window weight cavities must now be insulated by dense packed using a fill tube and entering from the lower sash access panel, installing foam, or by other comparable means. Re-install the access panels in the lower sash channels.

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3.10.3 Material

V-Seal type or equivalent vinyl weather-stripping with a deflection range of at least ¼ inch must be used. Materials must remain pliant in cold weather.

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3.10.4 Installation

All weather-stripping must be permanently installed with fasteners (tacks, staples, brads, etc.) and must make positive contact between surfaces to prevent air leakage. The weather-stripping must form an airtight seal when the window is closed and latched. A small bead of caulk must be applied if necessary to prevent air leakage behind the weather-stripping.

Weather-stripping must be installed on any sash, meeting rail or sill surface that leaks air as long as placement does not interfere with the smooth operation of the window.

1. “Three-sided” LOWER sash channels, & sill; or, if window has spring loaded channels: top, bottom and meeting rail.
2. “Four-sided” LOWER sash channels, meeting rail & sill.

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3.11 Door Weather-stripping

3.11.1 Location and Use

Air sealing priority must be given to weather-stripping doors to unconditioned attic spaces and attached garages. Additionally, weather-stripping of doors between conditioned and unconditioned (or semi-conditioned) space may be treated.

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3.11.2 Materials for Door Weather-stripping and Sweeps

Materials must:

- Be durable enough to withstand years of use
- Be reinforced with metal or wood
- Be capable of sealing the gaps around the door, and with enough flexibility to adjust for seasonal expansion and contraction of door and framing materials.
- Have a deflection range of at least ¼ inch and remain pliant in cold weather.

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3.11.3 Installation

1. All weather-stripping must be permanently installed with fasteners (tacks, staples, brads, etc.) and must make positive contact between surfaces to prevent air leakage.
2. The weather-stripping must form an airtight seal when the door is closed. A small bead of caulk must be applied as necessary to prevent air leakage behind the weather-stripping.
3. The weather-stripping must not interfere with the smooth operation of the door.
4. One of two types of sweeps must be used on exterior doors. Which sweep must be used depends on frequency of door usage. Doors that have high usage must be swept with a spring-loaded sweep that will only engage and contact the floor when the door is closed. Low use doors can have either the spring-loaded sweep or a non-retracting sweep that always makes contact with the floor.
5. After the weather-stripping is installed the door must be tested for ease of use. It must not be necessary to slam or exert excessive force on the door for the lock set to engage.
6. In addition to weather-stripping of doors and windows it may sometimes be necessary to install window sash locks, eye hooks, barrel bolts, etc. to make the installed weather stripping engage effectively.

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3.12 All Insulation

3.12.1 General

The following applies to all insulation installed through the program:

1. Install attic, basement wall/ceiling, garage, and wall insulation upgrades according to program eligibility criteria, based on customer work order.
2. Cost-effectiveness calculations must be based on effective R-values of pre-existing insulation.
3. Insulation materials and levels installed must match what is specified on the work scope as well as any contracts provided to the customer.
4. Insulation levels on retrofit projects must conform to code requirements for new construction to the extent that allowable space, program budgets, and customer agreements allow.
5. Particular attention must be paid to exposed foam insulation. See Appendix B-5 for fireproofing requirements.
6. Upon completion of the work the home and it grounds will be returned to their original condition. All construction debris and materials will be removed; windows and doors returned to original configuration, storage placed back in original areas etc.
7. Combustion safety screening and/or testing is required before and after air sealing, and with all projects in which enclosed cavities that are insulated represent 25% or more of the shell area.
8. ○*OPTIONAL BEST PRACTICE*○ Leave documentation of installed insulation levels, material or bag counts, and insulated area at the electrical panel or when it is not possible to leave it at the electrical panel, with the customer.
9. ○*OPTIONAL BEST PRACTICE*○ Install strategic dense blown insulation in enclosed cavities, to control air leakage and increase insulation levels in attic, basement, and living space cavities.
10. ○*OPTIONAL BEST PRACTICE*○ Ensure that all ductwork in an unconditioned attic is insulated to the same level as the remainder of the attic/conditioned space boundary.

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3.12.2 Measurement of Areas

1. There are three locations from which components of a building can be measured: outside, in the living space, or in a buffer zone such as an attic or crawlspace. Measuring from the outside is always preferred. When the building floor plan and the area to be insulated, such as the attic floor plan, are the same, exterior dimensions may be used.
2. Interior measurements from the living space (preferable) or from inside the attic/kneewall space (second option if living space measurements are inconvenient or not accessible) may be used for attic areas that do not match the building floor plan, such as knee-walls, slopes, cathedral ceilings, kneewall floors and attic flat areas that are smaller than the building floor plan. When interior measurements are used, then an additional foot should be added to each dimension to compensate for exterior wall thickness.
3. When taking measurements, round up to the next half-foot. For example, if the dimension is between 24 feet and 1 inch or 24 feet and 5 inches, the contractor may round up to 24 feet 6 inches (24.5 feet).

4. If software requires measurement in *net* square footage, the net wall area determined by:
    a. The exterior perimeter multiplied by the interior wall height(s). One (1) extra foot of height must be added for band joist perimeter of floor system between two conditioned floors if the home is balloon framed, or if the home is platform construction, and if the insulation project will include the band joist area.
    b. Basic windows and doors must then be deducted from this area. Large sections which cannot be insulated, such as brick walls or fireplaces must be deducted and noted on insulation work orders.

    If *gross* square footage is required, this can be determined by 4.a., above.
5. If exterior dimensions cannot be taken for the building shell and interior dimensions are used, an additional two linear feet must be added to the perimeter before it is multiplied by the interior wall height.

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3.12.3 Physical Properties

Insulation materials must satisfy the following national standards:

1. Batts - ASTM C 665
2. Loose fill (blown) cellulose - ASTM C 739
3. Loose fill (blown) fiber glass - ASTM C 764
4. Loose fill (blown) mineral fiber – ASTM C 764
5. Preformed polystyrene boards - ASTM C 578
6. Preformed polyurethane/polyisocyanurate boards - ASTM C 591

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3.13 Attic & Roof Slope Insulation: General

3.13.1 Sealing Bypasses Prior to Insulating

Before insulating the attic, the contractor must ensure that all identifiable bypasses through the attic floor, or at attic transitions (i.e. changes in ceiling height) have been sealed. Areas of concern include:

- Chimney edges
- Soil stacks
- Recessed lights and electrical boxes
- Openings into perimeter walls
- Tongue and groove gaps in ceilings
- Dropped ceilings
- Hatches, doors or recessed drawers leading into unconditioned kneewall attics
- Bypasses between conditioned area floors and unconditioned kneewall attics
- Bypasses between conditioned knee wall attics and unconditioned slopes.
- Open-top window weight boxes in gable or eave-side walls that terminate at or in the closed-cavity slopes

○*OPTIONAL BEST PRACTICE*○ Use visual inspection and infrared in combination with the blower door to determine leakage paths.

○*OPTIONAL BEST PRACTICE*○ Use Zonal Pressure Diagnostics to ensure that all identifiable leakage paths have been addressed.

Photo: Diagram of General Air Leakage Paths.

3.13.2 Attic Stairwell walls and stairs

If an attic area is determined to be outside of the thermal envelope, and attic insulation is to be proposed, the contractor must consider insulation of the stairwell wall between the conditioned space and the stairwell, including any wall area above and around the access door. Additionally, the cavity beneath the stairs must be considered if a conditioned space exists directly below.

○*OPTIONAL BEST PRACTICE*○ Insulate these areas. This eliminates a major thermal bypass.

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3.13.3 Material

Loose blown, batt and rigid foam board insulations in attic spaces must meet the appropriate guidelines listed in Section 3.12.3: Physical Properties. Where the brand name Thermax is specified for rigid foam board, an equivalent foam board that is rated for exposure to conditioned areas without a thermal barrier may be used. Otherwise the foam board must have a thermal or ignition barrier as specified in Appendix B-5. Area spray foams must conform to Appendix B.

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3.13.4 Installation

When insulating at the perimeter of the attic, the contractor must ensure that:

1. Air flow from soffit vent openings into the attic cavity is not impeded to any degree by the insulation.
2. The insulation is protected from the effects of wind-washing
3. The insulation at the edges of the conditioned space, including the top plate, is supported in such a manner as to maintain the desired depth and R-value for the life of the insulation and to prevent loose-fill insulation from falling into the soffit.

Baffles

1. Baffles must be installed at each soffit vent unless appropriate structural barriers exist to ensure appropriate air flow and protection from wind-washing.
2. Baffles must be permanent, mechanically fastened at sides and at bottom, and ensure the free movement of air through soffit vents into the attic.
3. Baffles must be rigid enough to restrain loose-fill insulation from congesting the soffit vents at the eaves and obstructing ventilation. These baffles must extend above the final level of resulting insulation by at least four inches, so to be visible upon inspection.

4. Pre-formed baffles are available, but baffles can also be made using rigid foam board, structural insulated sheathing, framing lumber, plywood, or OSB.
5. ○*OPTIONAL BEST PRACTICE*○ Wind washing at the eaves can be stopped by installing a rigid, air impermeable baffle that extends from the outer edge of the exterior wall top plate to within two inches of the roof sheathing and is attached to the joists on either side of the cavity that is being protected.

   Photo: Insulation Wind Wash Baffle.

Attic Hatch Damming

Permanent dams must be installed around all attic hatch covers in the following manner:

1. This damming may be accomplished by using unfaced fiberglass batts of greater thickness than the installed insulation placed around the perimeter of the hatch, by using a framing lumber fixed in place around the hatch, or by using rigid foam boards of sufficient thickness as to provide permanent support to the surrounding insulation.
2. The damming must not interfere with the opening of the hatch cover.
3. When the hatch is opened, the damming must prevent loose-fill insulation from falling into the living area.
4. The damming must allow for easy access into attic for future inspection.
5. Insulation levels immediately surrounding the hatch must equal or exceed the R-value of the rest of the attic space.

Electric Radiant Strip Heating Elements

Blown-in or faced insulation must not be installed in contact with electric radiant strip heating elements. A minimum 3-inch thick un-faced mineral wool fiber batt must be installed first.

Bathroom Fans

All bathroom fans must be dammed, using unfaced batts or other permanent enclosures, and vented through the roof with insulated ductwork that terminates at roof or eave vent with a spring-loaded damper. Bath fan venting must not terminate anywhere inside the building shell. (i.e. duct must not be laid into soffit area, or hung near gable vent, with termination within attic.) If roof penetrations are prohibited, an alternative route must be devised. Care must be taken to ensure that duct routes do not bow in such a manner as to create the opportunity for pockets of water to collect within the duct.

Flooring

If homeowner so desires, when attic flooring is removed, it must be reinstalled and screwed securely back into place. The contractor must remove and replace any flooring damaged during installation with a like product that is fastened securely.

Open Blow Insulation

Loose fill blown in insulation must be installed according to manufacturer's specifications and recommended densities. All open blow attics must be installed to a level condition. Photo: Loose Fill Attic Insulation Evenly Installed. Insulation in open blown areas must have minimum material count per

manufacturer's instructions, as follows: thickness as specified in work order is average settled thickness. Insulation depth markers with numbers at least one-inch high must be installed at least one for every 300 sq. ft. throughout the attic space. The markers must be fastened to the bottom of the attic joists or trusses and marked with the initial installed thickness. All depth markers must face the attic hatch. A cellulose table and example is provided below.

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Table 5. Example of a Cellulose Table

Example: Work order specifies 12 inch cellulose open blow. R-value from chart is R-42. Attic area is 1000 sq. ft. Look at chart on product bag, if chart says that installed R-42 = 60 bags for 1,000 sq. ft, you need to install 60 bags. Minimum thickness specified on work order also applies.

Inches on work order	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Installed R-value	11	14	18	21	25	28	32	35	39	42	46	49	53	56

1. Use depth charts provided by the manufacturer as a guide to specifying the number of inches to be installed. The installer will need the depth estimate to monitor insulation installation amounts. The depth and desired R-value must be checked periodically to ensure that the projected number of bags for the desired density are being installed.
2. Damming: Blown in insulation must be contained using damming at the following areas and listed clearances: chimneys & double wall flues (3 inches), single wall flues (6 inches), Recessed lights or bath fans with heat lamps or lights (3 inches). Attic hatches or pull-down stairs, whole house fans, mechanical access walkways, air conditioner drip pans, and storage areas (no clearance required). **Photo:** Attic Insulation Dammed Away from Chimney.
3. In situations where the dwelling has a whole house fan of the type that sits horizontally on the attic floor and draws air upwards through a louvered area below:
    a. If left untreated, the louvered area, even when closed, may allow air leakage into the attic. The contractor may consider creating a cover if practicable, to reduce this leakage.
    b. The contractor must always discuss any modifications to the whole house fan with the customer prior to initiating changes.
4. Loose Blown Insulation on Slopes: Loose blown insulation must not be blown onto unenclosed attic slopes with a pitch of more than 4:12. If loose blown insulation is blown on a slope that terminates at the end of a tray ceiling or other vertical wall open to the attic flat, the end of the sloped surface must be dammed with unfaced fiber glass of sufficient depth to maintain the specified R-value and the blown insulation must be installed up to the dam.

Dense Pack Insulation

1. Blown in insulation in restricted or dense packed applications must be 3.5 lbs./cu. ft. for cellulose and 2.2 lbs./cu. ft. for blown fiber that is manufactured for dense pack installation.
2. All openings into the cavity must be sealed in such a manner as to prohibit the insulation from coming out of the cavity.

3. If dense-packed insulation is used to insulate and air seal the joist cavity beneath an attic knee-wall, the cavity must be sufficiently packed and sealed to make it extremely difficult to detect any air movement with infrared (IR) scan and blower door.
4. ○*OPTIONAL BEST PRACTICE*○ Ensure that an area has been properly dense-packed by one of the following verification tests:
    a. Core sampling in 4 locations indicates the installed insulation has a density of at least 3.5 lbs./cu ft for cellulose and 2.2 lbs./cu ft for fiberglass that is approved for dense packing. This is the most reliable option. Core sampling is sometimes used by Program Quality Inspection teams.
    b. The blower door used in conjunction with an IR camera reveals no accessible major bypass leaks and less than 10% of the accessible top plates unsealed in an attic. For walls the IR camera must see no movement of air from bay to bay or through drywall penetrations. This method helps assure adequate coverage but may not ensure dense-packing.
    c. Proper insulation densities and depths may also be calculated by performing area and volume calculations and "bag counts".

Platforms

An attic storage platform may be built at the customer's expense if they wish to raise the attic floor for more room for insulation. The storage platform must have at least 2x6 frames. Contractors must ensure that the platforms are constructed with metal fastenings, and have sufficient structural integrity to support the weight of storage items, occupants and others who may access the attic.

○*OPTIONAL BEST PRACTICE*○ As an alternative to using structural framing and either dense packing or loose blowing below the storage deck, foam board can be used to gain a higher R-value within the cavity below the deck. The foam board should be supported structurally in such a manner as to maintain the integrity of the foam board insulation.

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3.14 Wall Insulation

3.14.1 Materials

Installed insulation materials must meet the appropriate guidelines listed in Section 3.12.3: Physical Properties

Exterior drill and plug repair on painted wood surfaces must include insertion of a wooden plug and exterior spackling or equivalent. Interior drill and plug applications through drywall or plaster must include the use of a plug and joint compound.

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3.14.2 Pre-Installation

Interior & Exterior Inspections
Prior to starting a job, an interior and exterior inspection must be conducted to determine any potential problem areas. These problem areas must be identified and addressed prior to working on that area. Examples of some problem areas are recessed radiators, duct work in wall cavities, recessed bookshelves, stairways on exterior walls, loose or cracked plaster on walls, poor siding, etc. Check wall areas for valuables that must be removed prior to working on walls. The process and the work that is to be performed must be explained to the client.

For buildings with masonry exteriors, the contractor must confirm through visual observation that there is a barrier in the wall system that will prevent blown in insulation from coming into contact with the masonry. The purpose of this observation is to ensure that the insulation will not absorb moisture when the masonry gets wet. The visual observation can be with the naked eye or via borescope and must be done for each cavity that is being insulated. This barrier will typically be in the form of sheathing attached to a frame wall, but other systems that separate the insulation from the masonry are also appropriate.

Avoiding Hazards
Ensure that the insulation of the cavities does not present a hazard to the occupant, installer or the home's structural/mechanical integrity, i.e., heat ducts, recessed lights, vent fans, electrical service entrances, etc.

Knob & Tube Wiring
Verify that knob and tube wiring has been replaced. Receive certification that existing knob and tube wiring is not live. (See Section 2.3: Knob-and-Tube Wiring for complete policy).

Moisture
Ensure that the moisture conditions detected in the structure are corrected prior to insulation of the sidewall cavities. This may be accomplished by one or more of the following techniques:

1. All cracks and holes between wall cavities and high moisture areas (kitchen, bathrooms, etc.) should be thoroughly sealed.
2. A vapor barrier may be installed, when possible, on the interior surface of the walls in bathrooms, kitchens, laundry rooms, and any other high moisture areas.
3. A vapor barrier floor covering, and possibly mechanical ventilation should be installed into high moisture crawlspace areas as per Section 3.15.3: Ground Cover
4. Exterior structural flaws that admit rainwater into wall cavities must be corrected: repair gutter, downspout, drainage system, and seal gaps above door/window casings.
5. An adequate moisture control system may be installed in the house, including indoor mechanical ventilation and passive attic ventilation.
6. Clothes dryers must be vented to the outside.
7. The owners/occupants should be advised to consider lowering their humidifier and/or to change lifestyle practice, which contribute significantly to high humidity.

Sidewall Openings
Ensure that all openings in sidewalls through which the insulation can escape to the interior or exterior of the building are blocked as follows:

1. Missing interior wall surfaces must be covered with a compatible material (i.e., drywall) and sealed into place. Generally, this must be done prior to beginning work.
2. Block all openings in sidewalls through which the insulation may escape. Seal all wall cavities which open into a basement or crawlspace before wall insulation is installed. Also check for pipe openings that enter kitchen cabinets and block them as needed.
3. Wall cavities with no top plate and/or open at the sill plate must be blocked and sealed with an air impermeable barrier, such as rigid polystyrene insulation.

In situations where missing or damaged exterior siding exist on the dwelling, the contractor must ensure that any opening that may allow moisture intrusion into the wall cavities are addressed in a manner that provides permanent protection of the insulation from water intrusion.

Siding
Because the siding on a house is the most obvious indicator a homeowner will use to judge the quality of an insulation job, it is extremely important that the siding work is done properly. Contractors must always explain to the homeowner how the siding will be removed and replaced before beginning work.

○*OPTIONAL BEST PRACTICE*○ Take photographs of the before and after siding conditions.

○*OPTIONAL BEST PRACTICE*○ Document final condition of siding in writing with the customer.

Siding Removal
1. Siding must be removed with great care to minimize stray marks, splits, and broken siding.
2. In cold weather, extreme care must be taken to avoid cracking vinyl siding.
   ○*OPTIONAL BEST PRACTICE*○ If practicable, contractor may defer vulnerable vinyl sidewall insulation for warm weather.
3. Bevel cuts on wooden siding can be helpful in reducing the risk of water migration behind the siding.
4. Great care should be taken in working around windows, doors and corners to avoid damage to trim.
5. ○*OPTIONAL BEST PRACTICE*○ Ensure that workers have clean hands, or use gloves, to avoid fingerprints or stains.

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3.14.3 Installation

Dense Pack Insulation
Blown in insulation in restricted or dense packed applications must be 3.5 lbs./cu. ft. for cellulose and 2.2 lbs./cu. ft. for blown fiber that is manufactured for dense pack installation. The cavity must be sufficiently packed and sealed to significantly reduce air leakage. For an effective installation use only equipment

compatible with the insulation material used. Follow manufacturer's recommendation for air pressure and density.

○*OPTIONAL BEST PRACTICE*○ Ensure that an area has been properly dense-packed by one of the following verification tests:

a. Cellulose: core sampling in 4 locations indicates the installed insulation has a density of at least 3.5 lbs./cu. ft. This is the most reliable option. Core sampling is sometimes used by Program Quality Inspection teams.
b. The blower door used in conjunction with an IR camera reveals no accessible major bypass leaks and less than 10% of the accessible top plates unsealed in an attic. For walls the IR camera must see no movement of air from bay to bay or through drywall penetrations. This method helps assure adequate coverage but may not ensure dense-packing.
c. Proper insulation densities and depths may also be calculated by performing area and volume calculations and "bag counts". Keep a record of the number of bags used to insure the installed insulation conforms to the manufacturer's recommended coverage shown on the material label.
d. Use smoke devices to test dense-packing: Dense-pack one bay. Use the blower door to depressurize the dwelling, set at 50 pascals with respect to outside. Use a smoke puffer to generate smoke at the drill hole of the insulated cavity. If the smoke is drawn into the cavity, adjust the material and air settings on the insulation machine and reblow the bay. Repeat the test until the smoke is not drawn into the cavity when the house is under pressure.

Drill and Plug (D&P) Applications

All blown in wall insulation should be installed with minimum 2 1/8 inch holes. Locate entry holes in walls to permit complete filling of wall cavities. Be sure to use sharp drill bits designed to cleanly cut holes with no tear out or other surface damage, properly sized for the wooden plugs being used. Speed-bore bits must not be used for this application.

Interior Applications

1. Interior drill and plug applications include attic stairway walls and treads, interior walls deemed to define the thermal boundary and exterior walls (when not done from the outside).
2. Before beginning work on interior drill and plug applications the area to be worked on must be cleared of as much homeowner property as possible. Remaining large pieces of furniture etc. must be protected by covering with drop cloths and sealed tightly, or by similar means. The area to be drilled must be sealed tightly from the remainder of the house using polyethylene sheeting, extension poles and duct tape. If the dwelling walls contain plaster and lathe, rather than drywall the interior wall holes must be staggered horizontally to avoid drilling out the same row of lathe as this weakens the wall and can cause large sections to detach.

○*OPTIONAL BEST PRACTICE*○ It is recommended that two drills be used for the interior drill process. The first drill will be used to cut through the plaster and will be very dull. The second drill will be used on the same hole after the plaster has been cleared to cut cleanly through the lathe and minimize pulling and cracking.

○*OPTIONAL BEST PRACTICE*○ An example of the drilled and plugged hole should be made in an inconspicuous place and shown to the owner at the beginning of the job for approval.

Exterior Applications

1. When drilling holes through siding that cannot be removed, and that has no repeating reference marks (such as Texture 1-11, novelty siding, knotty pine siding, frieze boards, and any other sheathing type siding) the holes must be drilled in a straight horizontal line.
   ○*OPTIONAL BEST PRACTICE*○ Use a laser level or chalk line to keep the plugs level across the wall. Do not use waterproof chalk.
2. Holes must be drilled as neatly as possible through all siding and sheathing materials, including plaster and wallboard.
3. During the hole drilling process, cavities must be probed in FOUR directions (left, right, up, and down) to ensure stud and blocking locations are correctly identified and blind bays are not left un-insulated.
4. The contractor must not leave holes in wall open overnight. Any holes must be plugged at the end of the day if work is not complete.
5. ○*OPTIONAL BEST PRACTICE*○ One-hole installation method. Use a fill tube to ensure consistent insulation coverage and density. Only one hole is needed per cavity if a fill tube is used, provided the tube is long enough to reach both ends of the cavity from the opening.

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3.14.4 Post-Installation

General

1. Before replacing the siding, the existing drainage plane must be returned to a condition that ensures drainage of any moisture that may penetrate the exterior cladding. (All exterior claddings pass some rainwater.) All holes opened in a wall must be covered or closed. Acceptable materials include: 15# felt paper stapled in place, wood, cork, Styrofoam plugs. Materials must be permanently caulked to prevent moisture intrusion.
2. All types of siding must be reinstalled with permanent metal fastenings as close to its original condition as possible, ensuring that the siding is weather tight. Fastenings must not detract from the appearance of the siding. Finish nails or comparable fastenings are recommended; however, vinyl siding should not be nailed unless pre-drilled. Vinyl or aluminum siding must not be face-nailed.
3. New siding installed to replace siding damaged by the contractor must match the original siding to the greatest extent possible. Wooden siding must be primed white (pre-primed in inclement weather) on the front, back and both ends, and painted or stained to match the original siding.
4. All patching and painting must be done with materials appropriate for exterior use. Patching of small areas may be done using a paintable siliconized acrylic caulking compound.

Repair of Drill and Plug (D&P) Applications

1. All drill and plug applications must be sealed upon completion of work.

2. In situations where the plug is recessed, at least one coat of spackling compound or comparable product must be applied. The contractor must ensure that the compound used does not have a tendency to shrink or crack.
3. In situations where the project is provided with full incentives through the Program, all drill and plug interior applications must be spackled to a smooth surface and painted to match the surrounding walls. Exceptions may be made only if agreed to in writing by the customer and approved by the Program.

Exterior Applications

Exterior D&P applications on painted surfaces must be completed in the following manner:

1. After installation, insert the plug so it is slightly (approximately 1/16 inch) recessed.
2. Apply one coat of an exterior rated sealer (exterior vinyl spackling or equivalent) and use a putty knife to bring sealant close to flush to the exterior siding.
3. This procedure also applies to drill and plug applications on windowsills, frieze boards, and entrances.

Exterior drill and plug applications on stained surfaces must be completed in the following manner:

1. After installation, insert a plug so that is it flush with the existing siding and the wood grains of the plug and the sheathing are in the same direction.
2. A small bead of caulk must be applied around the radius of the plug where it will contact the surrounding sheathing.
3. The plug must be installed flush with the siding. ○*OPTIONAL BEST PRACTICE*○ Tap it in place with a block of wood and a hammer.

Interior Applications

Interior drill and plug applications must be completed in the following manner: After installation, insert a plug so that it is slightly (1/16 inch) recessed. Apply one or two coats of patching material flush to the existing surface.

Work Review: Upon completion, contactor must ensure the following:

1. All the siding is repaired and/or reinstalled.
2. Paint touch-up is complete.
3. Shutters are reinstalled.
4. Yard, porches, driveways, and all exterior areas are swept clean.
5. Job documentation is complete.

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3.15 Basement and Crawlspace Insulation

Crawl spaces must be inspected for signs of standing water or existing moisture problems. Any existing moisture issues must be remediated before working to bring the crawl space inside the conditioned area.
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3.15.1 Locations and Use

Basements and crawlspaces may be insulated in one of two locations: on the interior side of foundation walls, or in the ceiling that defines the floor above. The decision where to insulate depends on the thermal boundary:

1. If the basement or crawlspace contains living space, heating equipment, laundry facilities, a water heater, distribution pipes or ducts, or water pipes, it is typically best to define the thermal boundary as the perimeter of the basement or crawlspace. In these instances the basement walls and rim joists should be considered appropriate for insulation. Basement ceiling insulation is likely to have minimal value.
2. If the crawlspace is open to a basement that is contained within the thermal boundary, the perimeter of the crawlspace should be considered the thermal boundary.
3. If a basement or crawlspace contains none of the equipment above and is not directly connected to a space within the thermal boundary, the area may be considered outside of the thermal boundary. In this situation the ceiling of the space may be considered appropriate for insulation.

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3.15.2 Material

Installed insulation must meet specification in Section 3.12.3: Physical Properties. Installed 2-part spray foam must meet specifications from Appendix B.

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3.15.3 Installation

Interior Wall Treatment

1. **A drainage plane or waterproof membrane must be installed between the insulation and the basement wall.**
2. A stud wall and batt system are not recommended for below grade applications due to its poor moisture performance, unless steps are taken to isolate the batt insulation and the wood framing from contact with the concrete wall or floor.
3. Insulation must be permanently fixed in place with a durable connection.
4. A non-absorbent insulation must be used.
5. Insulation must be continuous.
6. A constant air barrier must be installed on the warm side of the insulation and include floor-to-wall and wall-to ceiling connections. Insulation that provides an air barrier requires no further moisture barrier.
7. Thermal and ignition barriers must be installed as per code. See Appendix B for details regarding spray foam insulation requirements.

Ceiling Treatment

Batt Insulation

1. If faced insulation is specified, vapor barrier facing must be installed facing the heated space.

2. The insulation must be pushed into the floor bay far enough to ensure that the insulation contacts the sub-floor. Care must be taken not to compress the insulation more than necessary to achieve contact.
3. Insulation must be secured with support rods every 2 feet.
4. Areas above (freeze-ups and heat loss) and below pipes, ducts and around cross braces must be insulated. Insulation must be cut and fit neatly around all obstructions. Pipes and ducts must not be thermally isolated from the house.
5. Insulation must not be left exposed in areas of heavy use (house-wrap must be specified to cover insulation).
6. Crawl spaces exposed to the outdoors (unconditioned, ventilated crawl space) must have house wrap or equivalent installed beneath insulation for wind wash protection.

Dense Pack Insulation

1. All openings between the basement/crawlspace and the conditioned space must be sealed thoroughly.
2. A fiber reinforced membrane must be securely stapled to the floor joist at intervals of no more than 2 inches.
3. The membrane must be slit approximately every 6 feet and a fill tube used to dense pack the insulation to the density needed for the material used.
4. The slits must be sealed using a durable permanent tape or equivalent.
5. The area and cavity depth must be compared to the number of bags installed to verify density.
6. Crawl space exposed to the outdoors (unconditioned, ventilated crawl space) must have house wrap or equivalent installed beneath insulation for wind wash protection.
7. For a material to be considered field verified dense packed it must pass one of the tests in Section 3.14.3 Dense Pack Insulation.

Part Spray Foam

Follow procedures in Appendix B.

Ground Cover

A vapor barrier must be installed on exposed dirt floors, with the following qualifications:

Material Requirements

Minimum 6 mil polyethylene

Installation Requirements

1. Installed neatly and covering the entire area, with seams lapped a minimum of 12 inches
2. Seams sealed with a tape or sealant that provides a permanent, durable seal
3. Penetrations with foam, acoustic sealant, or compatible roofing mastic.
4. Perimeter edges run 10 inches minimum up wall and sealed to walls with acoustic sealant or roofing mastic
   a. Exceptions made only where access is impossible due to low clearance.

b. If vapor barrier is not present and not specified, or if proper installation is not possible, the situation must be brought to the attention of program field supervisor before work commences.

Photo: Crawlspace Ground Cover.

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3.16 Band Joist, Rim Joist, & Sill Insulation

3.16.1 Material

Installed insulation materials must meet the appropriate recommendations listed in Section 3.12.3: Physical Properties

Installed 2-part spray foam must meet specifications from Appendix B.

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3.16.2 Installation

1. If heat sources, such as heating or water heater exhaust vent pass through the rim joist area, the contractor must ensure clearances are maintained with fire-proof materials at a minimum to the distances required by Code from the heat source.
2. Any of the following or combination of the following methods may be used to insulate the rim and band joist:
   a. 2-part spray foam insulation may be used. In this application the foam can be extended from the subfloor to the junction of the foundation and the sill plate. In areas where termite presence exists, code may require an inspection break between the foam and the bottom of the sill. If there is a termite inspection break, then the seam between the foundation and the bottom of the sill must be sealed with caulk.
   b. The rim joist can be sealed by cutting blocks of 2 inch foam board to fit in the rim joist area and sealing the edges with 1-part foam. In this application the sill to foundation seam and the seam between the two sill plates must be sealed with caulk.
   c. If access to the gable wall joist bay prevents installation of 2 inch foam board, then the bay may be enclosed and the cavity dense packed. Care must be taken to ensure that the exposed foundation top is covered to prevent wicking into the insulation.
   d. Dense packed, blown-in insulation may be specified when basement ceiling is plastered.
   e. Batt insulation may be used in the rim and band area if the seams between the box beam and the sill, the floor joists and the box beam and the box beam and the subfloor have been sealed with either caulk or 1-part foam. If the batt insulation is faced the vapor retarder must be toward the warm surface. The batt must be cut large enough to be friction fit in the box sill area. Along gable walls (joists parallel to foundation wall), batts must be neatly installed and in full contact with exterior joist – full dimension batt may be needed to fill joist bay and held with metal rods.
   f. Exposed sill seal material is to be cut back to edge of sill and a sealant is to be applied where the sill plate meets the foundation wall.

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3.17 Knee Wall Attic Insulation

3.17.1 Material

Attic knee walls may be insulated with batt insulation, blown in insulation held in place by a restraining mesh, foam boards, or 2-part spray foam. Batt insulation must be protected from wind washing with an air barrier. Dense-packed cellulose may be deemed sufficient to protect the installation from the effect of wind washing if held in place a restraining mesh.
Appropriate materials for wind wash protection are building wrap, extruded poly styrene, insulated structural sheathing, plywood or OSB, or wall board.
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3.17.2 Installation

Insulating knee walls with batt insulation
Batts must be cut to fit and fill the entire bay. There must be no gaps, compression or stuffing of insulation. An air impervious wind wash barrier must be installed on the back side of the installed batt insulation. The air barrier must be pulled tight and mechanically fastened in place to ensure permanent attachment.

○*OPTIONAL BEST PRACTICE*○ Apply either staples every six inches for building wrap or screws every foot for rigid materials. Seams in the wind wash barrier may be sealed using building wrap tape on building wrap or 1-part foam on rigid materials.

Insulating knee-walls with blown in insulation and mesh
Knee walls can be sealed and insulated using dense pack cellulose or fiber glass. The density of the blown in material must be verified by using an area vs. coverage chart comparison or a smoke test as detailed in 3.14.3 Dense Pack Insulation. If the material is dense packed and protected by the fiber reinforced mesh, it is not necessary to install a wind wash barrier.

Insulating knee walls with 2-part spray foam
See Appendix B.
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3.18 Floors Over Unconditioned Spaces or Ambient Conditions Insulation

3.18.1 Overhang Insulation

General
Overhangs that were not sealed and fully insulated during construction are weak spots in a buildings thermal envelope. The sheathing material that is used on the underside of an overhang or even ventilated overhang floors are contributing factors to poor performance of this building detail.

Material

The insulating material that will be used to insulate an overhang can be dependent on access. If the overhang is unsheathed or accessible through the rim and band joist, the floor joist bay can be filled with batt insulation, dense packed or sprayed with 2-part foam. If the overhang is sheathed and there is no access through the rim and band, then the floor joist bays can be dense packed with blown insulation. If limiting the flow of blown-in material into the conditioned area of the floor bays is necessary, the inflated feedbag method described in Section 3.8.4/Air Barrier Aligns with Knee Wall & Attic Floor may be used.

Installation

Insulating A Cantilever (Overhang) With Batts

When an overhang is accessible because it is unsheathed or accessible through the transition area at the top plate fiberglass batts may be used to insulate the floor bays. Batt insulation must be installed to fill the entire cavity without voids or compression. The depth of the fiberglass batt must equal the depth of the cavity. Because fiber glass batts do not stop air movement the transition area at the top plate must be thoroughly sealed after batt installation and the sheathing that will be added to the bottom chord of the floor joists must be sealed to the surrounding finish with exterior rated caulk. Adding a layer of rigid foam board on the floor joist bottom before re-sheathing if conditions permit may be considered as an option to increase overall R-value and reduce thermal bridging.

Dense Packing A Cantilever

When an overhang is sheathed or otherwise inaccessible dense pack insulation may be used to reduce air flow and increase the R-value of this area. A thorough inspection of the floor joist bays that will be affected must be conducted before beginning work. Insulation must not be installed within 3 inches of recessed lights (unless they are ICAT). If heating supply or return ducts exist in the cantilever area, the contractor must ensure that the densepacking does not deform the duct or intrude insulation into the duct. If heat sources, such as heating or water heater exhaust vent pass through the cantilever, the contractor must ensure clearances are maintained with fire-proof materials at a minimum to the distances required by Code from the heat source.

If the overhang extends over the outside space more than 6 feet, additional holes must be drilled to ensure that the fill tube can reach all areas that are to be insulated, or a longer fill tube may be employed. The density of the installed insulation may be checked using a coverage chart and the number of bags installed or by de-pressurizing the house and checking for air movement at the drill holes with smoke. Once the floor bays are dense packed the drill holes must be plugged. If there are frayed edges at the drill holes the strands must be pushed into the drill hole and a wooden plug inserted. The wood grain of the plug must run the same way as the wood grain of the sheathing. The plug must be made flush.

○*OPTIONAL BEST PRACTICE*○ The flow of insulation can be controlled using the “feedbag” method described in Section 3.8.4/Air Barrier Aligns with Knee Wall & Attic Floor. The feedbag method is strongly recommended for use in every floor bay to control the flow of insulation into non-specified areas. When dense packing over hangs using the feedbag method the drill hole in each floor bay must be made as

close to the transition area where the floor joist passes over the exterior wall top plate as possible. The feed bag must be inserted there and inflated to block the rim joist area. Once the rim joist area is sealed with the inflated feedbag, the fill tube can be withdrawn, reinserted into the joist bay cavity and the remainder of the overhang dense packed.

Insulating an Overhang With 2-Part Spray Foam

If the overhang is unsheathed and accessible 2-part spray foam may be used to seal and insulate this area. The transition area at the exterior wall plate must be backed with a rolled batt. See Appendix B for the proper installation of 2-part spray foam.

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3.18.2 Frame Floor Over Garage Insulation

Batt Insulation

1. If faced insulation is specified, vapor barrier must be installed facing the heated space.
2. The insulation must be pushed into the floor bay far enough to ensure that the insulation contacts the sub-floor. Care must be taken not to compress the insulation more than necessary to achieve contact.
3. Insulation must be secured with support rods no more than 2 feet apart.
4. Areas above (freeze-ups and heat loss) and below pipes, ducts and around cross braces must be insulated. Insulation must be cut and fit neatly around all obstructions. Pipes and ducts must not be thermally isolated from the house.
5. Insulation must not be left exposed in areas of heavy use (house-wrap or equivalent must be specified to cover insulation).
6. Crawl spaces exposed to the outdoors (unconditioned, ventilated crawl space) must have house wrap or equivalent installed beneath insulation for wind wash protection. Drywall or an equivalent air barrier must be recommended for garage ceilings. House wrap can be used in garage applications if it is securely fastened with staples and the seams are sealed with house wrap tape.
7. If rigid board insulation is used as an insulator and a wind wash barrier or air barrier it must be continuous without gaps or voids and all edges and seams must be sealed with 1-part foam or equivalent.

Dense Pack Insulation

1. All openings between the garage, overhang or crawlspace and the conditioned space must be sealed thoroughly.
2. If a rigid air barrier (drywall, structural Insulated panels etc.) is already in place follow the same dense packing procedures as in Section 3.18.1 Dense Packing A Cantilever.
3. If there is no rigid air barrier in place, the following procedure may be used:
   a. A fiber reinforced membrane must be securely stapled to the floor joist at approximately 2 inch intervals.
   b. The membrane must be slit approximately every 6 feet and a fill tube used to dense pack the insulation to the density needed for the material used.
   c. The slits must be sealed using 3M 8086 tape or equivalent.

4. The area and cavity depth must be compared to the number of bags installed to verify density.
5. Crawl space exposed to the outdoors (unconditioned, ventilated crawl space) must have house wrap or equivalent installed beneath insulation for wind wash protection.

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3.19 Guidelines for Insulating a Mobile Home Belly

Prior to insulating

1. All plumbing leaks in the underbelly area must be permanently repaired, and all plumbing under the mobile home must be in good condition.
2. Pre-existing insulation condition and level must be evaluated.
    a. In the event that the under belly is in very poor condition and requires repairs that may be impeded by the installation of foam or other insulation, alternative methods of insulation, such as re-insulating with fiberglass, should be considered.
    b. In the event that the underbelly insulation is in generally good condition, with some areas of missing insulation. It may be more cost effective to repair the insulation.

○*OPTIONAL BEST PRACTICE*○ Probe in at least two places, and document condition with photographs.

3. Workscope must ensure that any pipes that will extend below the foam will be protected from freezing. If heat tape is required, ensure that the heat tape is installed prior to installing the belly insulation, and that occupants are educated on the use of the heat tape. Note: Heat tape must be treated as a heat source. Foam must not be installed within direct contact of heat tape.

○*OPTIONAL BEST PRACTICE*○ Boxing in water supply lines with foam board in such a manner that the enclosed water lines have access to heat.

4. The heating distribution system must be examined, and repairs made as needed prior to the installation of belly insulation.

○*OPTIONAL BEST PRACTICE*○ Visual inspection with mirror and flashlight, and diagnostic testing with pressure pan, with a goal of 3 Pascals or less of leakage per register.

○*OPTIONAL BEST PRACTICE*○ See all accessible duct work and eliminate all blockage.

Foaming the belly

1. Installation must comply with Appendix B: Spray-Applied Polyurethane Foam
2. The foam must be adequately supported to ensure long-term integrity.

○*OPTIONAL BEST PRACTICE*○ Use furring strips or fiber mesh to add structural support to the foam.

3. If the cavity between the floor and the membrane has a sidewall area (in other words, the membrane does not curve upward to meet the floor area) the sidewalls of the cavity must be included in the application.

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4. Attic, Roof & Crawlspace Venting

4.1 General

When attics are air sealed and insulated, they must be brought into compliance with state and local code requirements. The IRC 2015 defines required venting levels in Section R806.2. This section calls for a ratio of one sq. ft. of net free venting area for every 150 sq. ft. of attic area. This ratio can be decreased to one sq. ft. of net free area for every 300 sq. ft. of attic area if at least one of the following statements are true:

- A class I or II vapor retarder exists on the conditioned side, or
- If at least 40% and not more than 50% of the venting area is provided by ventilators located in the upper portion of the space to be ventilated not more than three feet from the ridge or highest point of the space, measuring vertically, with ventilation at the eaves or cornices providing the balance. In instances where framing members conflict with the installation locations, the higher vents can be more than three feet from the ridge. In practice this means that as much as possible vent openings must be equally spaced between areas high in the attic or slope and low in the attic or slope.

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4.2 Assessing pre-existing venting and required venting

1. The attic planes must be checked for the existence, location and condition of a Class I or II vapor retarder. Examples include: Kraft or foil facing on a batt, polyethylene sheeting or wall board with two layers of latex paint.
2. Once the class of vapor retarder is identified, the attic area (including vaulted areas) must be divided by either 150 sq. ft. if there is not vapor retarder or 300 sq. ft. if there is a vapor retarder. The result of this calculation is the amount of attic ventilation required by Code. Next, the existing ventilation must be assessed, the net free area calculated (see below), broken into high and low ventilation and subtracted from the appropriate high or low ventilation of the code required ventilation area. The results of subtracting the existing ventilation area from the code required ventilation area is the area of ventilation that must be installed to ventilate the attic to code levels.
3. Net free area vs. gross are: The actual amount of ventilation area provided by a vent depends on its “net free area.” Net free area is not the same as the external dimensions of any particular type of vent: it is the actual amount of area that allows air flow when the inhibiting factors such as vent louvers, trim and screening are deducted. Therefore, it is necessary to determine the amount of ventilation provided by the vents used by calculating their total next free area and comparing that to the attic’s ventilation requirements. Most vents have their net free area stamped on them. When in doubt, consult with the manufacturer before installing.
4. The contractor must ensure that all vent openings are cut in such a manner as to allow maximum air flow through the vent.
5. Continuous Soffit Venting: Newer homes may have continuous soffit venting installed when constructed. Continuous soffit vent typically has a net free area of 0.12 sq. ft. per linear foot. However, it is important to verify that the openings in the soffit vent are actually open to the attic area, and to calculate the actual net free area of the openings. Perforated drip edge is another form

of low ventilation. The integrity of the drip edge must be assessed before giving ventilation credit to it as it can be crushed during installation and its net free area reduced.

6. In some cases where attic height is very low, gable vents may be used as low ventilation. In these cases, it may be necessary to dam off the gable vent to keep it clear of blown insulation.
7. Placement of vents must be considered for proper air flow and must prevent entry of wind-driven rain or snow. The vents themselves must be configured to protect against the entrance of rain and snow.

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4.3 Preparation

1. Attic ventilation must only be installed if the presence of an effective air barrier and thermal boundary between the attic and the living space is verified, or if effective air sealing and proper insulation is specified as part of the work scope.

   ○*OPTIONAL BEST PRACTICE*○ Employ Zonal Pressure Diagnostics to evaluate the air sealing between the conditioned space and the attic.

   The existing condition of the attic plane may be tested to be tight by way of the blower door and pressure differential and visual inspection of all bypasses before more passive ventilation is added. If the attic plane is going to be tested with a blower door, the “Add a Hole” or “Open a Door” method may be used to quantify leakage across the attic plane. To be considered tight the CFM50 across the attic place must be less than 0.5 CFM50/sq. ft. with respect to the conditioned space.
2. All ducted exhaust equipment (bath fans, kitchen fans, clothes dryers) must be vented to the outside of the structure prior to any air sealing or insulation work performed in an attic.
   Ductwork contained in the attic must be sealed and insulated to at least R-8 before passive ventilation is added.

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4.4 Passive Attic Venting: Materials

1. Air vent types must be consistent with the requirements for their specific location (e.g., exterior soffit, gable end, roof) and material and intended use.
2. Air vents must be of color and appearance that is consistent with the exterior of the dwelling and acceptable to the customer. Mill finish vents must be spray painted to match house colors. Care must be taken when spray painting to avoid reducing the net free area by clogging the insect screen.
3. Typical sizing of vents is as follows:
   a. Soffit vents: 4x12, 6x12 and 8x12
   b. Gable vents: 12x12, 12x18, and 18x24
   c. Roof vents: Eight-inch diameter
   d. Ridge vents: Four and Eight-foot lengths
4. All attic vents must have screens of non-corroding wire mesh with openings between 1/16 to ¼ to prevent pest entry.

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4.5 Passive Attic Venting: Installation

1. All vents must be installed to manufacturer's specifications, properly flashed with roofing and siding materials and properly sealed to be watertight.
2. All vent opening must be cut to appropriate size for installed unit.
3. All installed soffit vents must have soffit baffles installed in the bays they ventilate, unless the housing configuration allows for a barrier between the insulation and the soffit area, and an air flow of at least 2 inches about the barrier. Continuous soffit vents must have soffit baffles installed in as many bays as is needed to meet code requirements for low ventilation based on the net free area of the continuous soffit vent. Remaining bays must be protected from wind washing. Care must be taken to ensure that all vent chutes remain clear of insulation and other obstructions.
4. Bath, dryer, or heating system vents must not be installed in or below the specific soffits that provide inlet ventilation to vented roof slopes or attics.

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4.6 Active (Mechanical) Attic Venting: Materials

1. The attic fan must be rated for continuous use. It must be capable of having its speed adjusted by a rheostat without being damaged, humming or vibrating.
2. The attic fan must be controlled by a thermostat that will activate the fan at a pre-set maximum temperature.

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4.7 Active Attic Venting: Installation

1. All electrical connections that need to be installed for this system must be installed by a licensed electrician.
2. The fan must be permanently mounted to roof or wall framing and have sound attenuators installed to minimize sound and vibration transfer.
3. If a vent needs to be installed to install the fan, the vent must be installed neatly and be tied into existing drainage planes. Roof or siding materials must be repaired/restored to original conditions.

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4.8 Basement and Crawlspace Venting

4.8.1 General

Section 408 of the 2015 IRC contains the following ventilation requirements for crawlspaces not included in or open to basements:

- No mechanical ventilation exists, and no Class I vapor retarder exists (see below): **1 ft2 of ventilation for every 150 ft2 of crawlspace floor area**
- No mechanical ventilation exists, but a Class 1 vapor retarder has been installed with 6 inch overlaps sealed and taped at the seams, and vents located in such a manner as to provide cross ventilation: **1 ft2 of ventilation for every 1500 ft2 of crawlspace floor area**
- **No additional ventilation is required** if a Class I vapor retarder exists as per above, and either:
    - A mechanical ventilation system installed capable of either exhausting or supplying 1 CFM/50 sq. ft. of area including an air path to conditioned area, and the perimeter walls are insulated
    - The space is heated by conditioned air and the perimeter walls are insulated
    - The space is used as a plenum

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4.8.2 Mechanical Ventilation: Material

1. Installed fan must be rated for continuous use and have a Sone rating of less than 1.0.
2. Fan must be controlled by an on/off switch as the fan must not run on a schedule. It must run continuously.
3. If the system is an exhaust system, there must be a vent termination with an integral pest screen and a back draft damper.
4. System ducting must be hard duct.

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4.8.3 Mechanical Ventilation: Installation

1. All electrical installations required for installation of this system must be installed by a licensed electrician.
2. The fan must be securely fastened to the floor framing system and sound attenuators must be used to minimize the transfer of vibration and sound.
3. If this is an exhaust system, the fan must be hard ducted to the exterior with the ducts supported every 10 feet.
4. The vent termination must be neatly installed and tied into the existing drainage plane. Exterior finish surrounding the vent must be returned to its original condition.
5. For exhaust systems contractors must ensure that there are adequate air paths from the conditioned space to the crawl space to relieve the pressure induced by the fan.
6. For supply systems the fan must be ducted to draw air from the conditioned space to deposit it in the crawl space.

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4.9 Fresh Air Ventilation for the Conditioned Space

4.9.1 General

The contractor must employ ventilation strategies that:

1. Ensure fresh air throughout the dwelling. In some instances, both whole house and local ventilation may be required.
2. Reduce or eliminate the risk of back drafting or drawing pollutants into the conditioned spaced.

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4.9.2 Material

Exhaust fans must:

1. Be rated for continuous use
2. Have a noise rating 1.0 sones or less.

Fan Controls must comply with the following:

1. Timers must consist of a 24-hour timer capable of automatically turning the fan on and off at pre-set times.
2. Fans must have an on/off switch separate from the timer that occupants may use for spot ventilation.

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4.10 Installation

1. Fans and 24-hour timers must be installed neatly and according to manufacturer's installation instructions.
2. Gaps between the fan housing and surrounding finished must be sealed with caulk or one-part foam.
3. Exhaust fans must be installed with air outlet facing in the direction that the duct will run to minimize the need for elbows.
4. All joints and seams in the air ducts must be sealed.

    ○*OPTIONAL BEST PRACTICE*○ Duct mastic

5. Exhaust Location: 2015 IRC Section M1501.1 forbids the venting of exhaust fans of any types into attics, soffits vents, ridge cents, or crawl spaces. All installed exhaust systems must terminate outside of the building. Exhaust vents must be vented to either a roof flapper vent, an end wall flapper vent or if neither of these two options is available, to an exhaust vent designed to be installed in a soffit. All exterior flapper vents must be equipped with a backdraft damper that works smoothly. Back draft dampers at the fan unit must be removed. Vent outlets must be properly flashed and sealed into roof or siding materials, so water will not leak into the assembly.
6. Exhaust ducting must be attached to the fan outlet and the flapper vent connector with metal clamps.

7. The duct must be insulated to current code levels for the location it passes through. The duct insulation must have a vapor retarder covering.
8. Hard duct must be supported every 10 feet with 1-inch metal straps. Flex duct must be supported according to manufacturer's instructions.
9. All joints in the duct must be screwed securely at a minimum of 3 points with no more than 3/8-inch screws.
10. Manufacturer's literature for fans and control device must be left with the homeowner.
11. Installed fresh air intakes must not be within 10 feet of any pollutant source. In cold climates it must be at least two feet above grade. There must not be a back-draft damper as part of this vent. There must be a pest screen. The vent must be properly flashed and tied into the existing drainage plan and the existing siding must be repaired/replaced to the original condition.

    ○*OPTIONAL BEST PRACTICE*○ An in-line fan can be remotely mounted and connected to one or more bathrooms and controlled by a 24-hour timer. The in-line fan must be mounted with vibration attenuators. Photo: In-line Exhaust Fan Ventilation

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4.11 Additional requirements specific to kitchen ventilation

4.11.1 General

Kitchen venting must comply with 2015 IRC Sections M1503 through M1507.

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4.11.2 Materials

1. Kitchen exhaust fans must be capable of exhausting 25 CFM continuously or 100 CFM intermittent. Any kitchen exhaust system that exhausts more than 400 CFM must have a makeup air system that conforms to M1503.4.
2. Ducts connected to kitchen range hoods must be constructed of galvanized steel, stainless steel or copper. The ducts must have a smooth interior surface, must be air tight and must have a back draft damper installed.

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5. Exterior Window & Door Measures

5.1 General

This section covers window and door replacements, and window insulating panels.
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5.2 Storm Windows

5.2.1 General

A high quality well installed storm window can significantly improve the performance of a primary window. In addition to lowering U-factors and Solar Heat Gain Coefficients, if the window is installed level and square and caulked correctly it will make a leaky primary window tighter.
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5.2.2 Material

1. All storm windows must conform to the standards determined by the American National Standards Institute/Architectural Aluminum Manufacturers Association (AAMA 1002.10.93).
2. Storm windows must be aluminum, combination, triple-track type, complete with operating sashes and screen insert.
3. Interior storm windows must have a rigid frame that clip easily into place. Interior storm windows are exempt from the air tightness standard.
4. Air leakage rates must be according to ASTM E283:
    a. Air leakage for fixed panel storm windows must not exceed 0.15 CFM per sq. ft. of window area at both a positive (infiltration) and negative (exfiltration) static pressure of 1.56 PSF at 25 mph wind. Weep holes must not be sealed during the air leakage test.
    b. With the storm window sash in the closed position, air leakage in removable panel, horizontal and vertical sliding windows must not exceed 0.50 CFM per lineal foot of sash crack at both positive and negative static pressure 1.56 PSF at 25 mph wind. Weep holes must not be sealed during the air leakage test.

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5.2.3 Installation

1. The four window sashes, meeting rail, sill and head jamb must either interlock in a tongue and groove manner or be weather-stripped with wool pile and/or silicone treated wool pile or equivalent.
2. Window must be installed squarely so that storm windows and screen operate smoothly.
3. No adjustments to window opening must be made to accommodate a mis-measured product.

4. Continuous, substantial bead of caulk must seal exterior storm to casing of dwelling; effective weep hole(s) must be created at the sill. The expander bars at the bottom of the storm windows must be caulked from the inside.
5. Interior storm windows must be clipped or screwed in place. If over 48 linear inches, must be double strength or tempered glass.
6. All windows must be installed according to manufacturer's specifications.

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5.3 Replacement Windows

5.3.1 General

While window replacement is not generally a cost effective energy saving upgrade, there are times when window replacement may be recommended. Typical reasons are aesthetics, existing windows don't function, or existing windows structurally deteriorated. If the windows are going to be replaced it makes sense to replace them with a high quality, energy efficient units.

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5.3.2 Material

1. All windows must be ENERGY STAR ® labeled.
2. Sealed glass units must be warranted against leakage for a minimum of five (5) years. All warranties must be provided to the homeowner.
3. The air infiltration rate must be 0.2 CFM/Sq. Ft. (at uniform static pressure of 1.57 lbs./sq. ft. (25mph) or less.

   ○*OPTIONAL BEST PRACTICE*○ Install double hung windows with tilt-in feature

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5.3.3 Pre-Installation

1. Where applicable, the homeowner must be informed about the lack of structural integrity of existing jambs if the window unit is to be secured to them. This must be assessed at the time of the first site visit, prior to signing the contract.

   ○*OPTIONAL BEST PRACTICE*○ At the time of the site visit, home assessor may provide a sample of the window unit to be installed. A cut-away view may be used.

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5.3.4 Installation

1. At the time of installation, the interior and/or exterior trim should be removed by first breaking the paint seal with a sharp tool, such as a utility knife and then removing screws or nails as carefully as possible to prevent breakage.
2. The installed window must be tested to ensure that it operates correctly and smoothly as the manufacturer intended and that all locking mechanisms and weather stripping engage as intended.
3. Existing balance systems and weights must be removed, pulley openings must be sealed over, pockets must be completely filled with dense pack insulation, foam, or other substance that provides insulation and eliminates air movement through the pockets. Jambs must be thoroughly caulked, so that the end product is an effective air barrier and insulated against heat loss around the window unit.
4. After installation, the exterior and interior trim must be in place, whether it is existing or new, and must be caulked as needed with a 20-year siliconized paintable caulk or equivalent and in a careful manner. The end product must be a continuous air barrier from the interior wall finish to the new sash unit.
5. Installed window must be integrated into the drainage plane. Pan flashing and head flashing must be installed.
6. At a minimum, completed window installation must be left touch-up paint-ready, with any damage to the window or frame repaired.

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5.4 Interior Window Insulating Panels

5.4.1 Material Requirements

Installed panels must be R-3 or greater.

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5.4.2 Installation Requirements

1. The insulating panels will be fastened to the interior finish framing of the window.
2. The insulating panel will be securely fastened using a fastening system that allow the insulating panels to be easily removed during warm months.
3. The insulating panel will have an airtight gasket between the panel frame and the finish frame of the window.

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5.5 Replacement Doors

5.5.1 Material

Doors must be ENERGY STAR ® rated door for climate zone.

5.5.2 Installation

1. The door must be installed according to manufacturer's directions.
2. The space between the framing and door jamb must be filled with either 1-part foam or silicone caulk and the casing must be caulked to prevent infiltration.
3. Door flashing must be tied into the existing drainage plane to minimize the potential for leaks.
4. Door must operate and lock easily.

6. Heating & Cooling Systems

6.1 General Requirements

1. All installed equipment must meet current ENERGY STAR ® requirements for efficiency for the climate zone in which they are installed.
2. All equipment must be installed in accordance with manufacturer's specifications.
3. Sizing:
    a. The contractor must ensure that the installed heating unit, along with any supplemental heat / emergency heat is appropriately sized to meet the heat load for the dwelling. NYS IRC Section R303.10 heating requirements must be met as follows: "… every dwelling unit shall be provided with heating facilities capable of maintaining room temperature of not less than 68°F (20°C) at a point 3 feet (914 mm) above the floor and 2 feet (610 mm) from exterior walls in habitable rooms at the design temperature."
    b. All installed space conditioning equipment must be sized in accordance with the latest version ACCA Manual-J or other approved equivalent. A list of ACCA-approved software can be found at:

        www.acca.org/standards/software

    c. A Blower Door (cfm50) test must be performed on existing homes whenever possible to estimate building air leakage rate for infiltration load assessment.
    d. Space conditioning equipment must be selected using the latest version ACCA Manual-S.
4. The contractor must ensure that the customer has access to technicians capable of providing servicing to the unit in a timely manner. This requirement extends beyond the contractor's warrantee period.
5. Installation must comply with the latest version of ACCA5: HVAC Quality Installation Specification in design, install and commissioning.
6. Installation must comply with requirements of the National Fuel Gas Code, including:
    a. NFPA 31: Standards for the Installation of Oil-Burning Equipment
    b. NFPA 54: provides minimum safety requirements for the design and installation of fuel gas piping systems in homes and other buildings.
    c. NFPA 58: provides for safe LP-Gas storage, handling, transportation, and use, and mitigates risks and ensures safe installations, to prevent failures, leaks, and tampering that could lead to fires and explosions.
7. All equipment and accessories must be designed and installed per manufacturer's specifications.
8. All air conditioning equipment must be Air Conditioning, Heating and Refrigeration Institute (AHRI) certified.
9. All equipment must be installed in compliance with state and local codes.
10. The contractor must ensure that the equipment is designed, installed and serviced by factory-trained personnel or the equivalent.

11. Ventilation calculations must be performed for every HVAC system installation/replacement with a proposal for a new ventilation system when needed.
12. Work must include the removal of all old heating and cooling system parts and material that will not be included in the new installation. An exception can be made if the old system will serve as backup or supplemental heat.
13. Maintenance panels shall be easily accessible and not blocked by refrigerant piping, wiring, building components, exhaust gas venting etc. All appliances shall have the minimum clearances required by manufacturer's specifications. All units shall be able to have components switched out for repair or replacement without requiring extensive dismantling of ducts, wiring, refrigerant lines etc. If the contractor discovers that the homeowner has placed items close enough to the appliance as to constitute a fire hazard, the contractor must require that they be moved a safe distance from it prior to installation.
14. All installed equipment or systems must be tested for combustion safety.
15. Start-up and commissioning:
    a. The contractor must secure, in an easily visible location, a sticker showing their name, regular phone number, emergency service phone number (if applicable), and date of system startup.
    b. There must be, either in the owner's possession or affixed near the unit, all installation and operating manuals and warranties.
    c. The contractors must complete and submit an ACCA 9 or manufacturer's commissioning sheet to the customer. The ACCA 9 version can be found at:

       http://www.acca.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=4e66c088-1175-d40c-64ef-247a17db7af2&forceDialog=0

    d. The contractor or his/her representative must instruct the owner on the complete operation of the system at the time of system startup.
16. All technicians or subcontractors who remove refrigerants from the premises are to recover/recycle refrigerants in compliance with EPA regulations.
17. When installing boilers or water heaters that draw water from the dwelling's water source, the contractor must ensure that water quality will not damage the installed equipment, especially if a dwelling draws water from a well. The contractor must ensure that installed system is protected from the detrimental effects of hard water, sediment, high or low pH, and high levels of chlorides in the domestic water. The following steps must be taken:
    a. The contractor must follow manufacturer's water testing requirements and retain copies of test results.
    b. The contractor must ensure that any required water treatment systems are in place prior to installation. The treatment must be compatible with materials of construction.
    c. The contractor must ensure that customer is made aware of any potential impacts of customer actions that may affect the quality of the water and the performance of the system and has been informed of all maintenance requirements.
18. Condensate must be piped, trapped, pitched, sized and insulated per manufacturer's specifications. Condensate disposal systems must be installed as to prevent freezing and must not terminate over

walkways**.** If condensate pump is installed, it must also have an interlocked detector / cutout switch installed so that unit is disabled if water level rises and activates detector / switch.

○*OPTIONAL BEST PRACTICE*○ Identifying the presence and quantity of moisture in addition to its source is a high priority issue when evaluating a building's performance. Undesirable moisture levels can occur as a result of diffusion through high permeability building components in contact with the ground, or bulk water transport through vulnerabilities in the exterior envelope. In the enclosed space of a basement, moisture whether in the vapor phase or as bulk water, can contribute to mold development, building and mechanical equipment durability issues such as wood decay and corrosion of metallic equipment, and other indoor air quality concerns. Common strategies to mitigate moisture intrusion in the living space are often focused at the basement / crawlspace level.

For these reasons it is a ○*OPTIONAL BEST PRACTICE*○ to route the condensate that is produced from combustion appliances and cooling coils directly to an enclosed drain system. This could include existing plumbing which conveys wastes to a treatment system or directly to a passive (gravitational) or actively pumped system leading to the outside of the building. If none of the above approaches are available to pipe condensate directly to an enclosed piping or sump system, installing a condensate pump is the ○*OPTIONAL BEST PRACTICE*○ to ensure that the high efficiency equipment that is installed is not creating a moisture problem or contributing to an existing moisture problem.

Routing condensate along an open interior perimeter trench is not sufficient because it can allow this liquid to evaporate into the basement before it reaches the sump or absorb into the slab and possibly collect in the soil under the slab. These scenarios can contribute to undesirable moisture levels.

19. All combustion gas venting systems must be run to the exterior of the building and terminate with an approved end cap.
20. Venting:
    - Appliance venting must have the proper sizing, design, material selection and assembly for the combustion fuel venting system as per applicable codes and manufacturer's specifications.
    - The contractor must ensure that all pre-existing and installed venting has the proper pitch, with a minimum slope of ¼ inch per foot or according to manufacturer's specifications.
    - All unused openings in venting system must be sealed.
    - The contractor must inspect existing flues which will have continued use, either by the new system, or by other appliances which may be "orphaned" by the installation of a new system with an alternative flue. Flues must be sized and lined as required by the National Fire Protection Association (NFPA).
    - The contractor must ensure that there is no blockage or restriction, leakage, corrosion and other deficiencies which could cause an unsafe condition. Chimney must be cleaned as needed to ensure continued safe operation.

- All positive pressure combustion gas venting systems must be sealed tightly.

21. All installed systems must have both the combustion air intake and the combustion gas exhaust piped to the exterior.
22. All piping and venting must be appropriately supported.

○*OPTIONAL BEST PRACTICE*○ Prior to installation provide customer with a written description of critical aspects of the installation, such as make and model numbers, locations identified for installation, planned location of line sets, etc. Obtain a signature that confirms agreement by the customer.

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6.2 Additional Requirements Specific to Natural Gas or Propane Systems

1. All positive pressure combustion venting systems must be sealed tightly and appropriately supported.
2. Gas Piping:
    a. All gas piping to be leak-free / tested and must be sized to provide adequate gas supply to all connected gas appliances. Refer to NFPA 54 (natural gas) or NFPA 58 (propane) and local codes for gas piping requirements and sizing.
    b. Gas piping systems must be of such size and installed as to provide a supply of gas necessary to meet the maximum demand of the all gas appliances at the proper pressures.
    c. Gas pipe and connectors must have the appropriate supports, hangers, anchors and gas pipe sealant.
    d. The new appliance must have a manual “equipment” shut-off valve in the gas supply line immediately upstream of union. A ground-joint union and a drip leg must be installed immediately upstream of the appliance.
3. Grounding of Gas Piping
    a. All gas piping must be grounded as required by the International Residential Code (IRC).
    b. Yellow-jacketed Corrugated Stainless Steel Tubing (CSST) must be bonded to the electrical service grounding system or, where provided, the lighting protection electrode system. Refer to section G2411.1.1 of the IRC for further details and requirements.
    c. Black-jacketed CSST which has been tested and listed to ICC-ES LC 1024 “CSST Utilizing a Protective Jacket”, may not require the additional direct bonding required for Yellow CSST (above). Consult with local code officials as to requirements.
    d. Non-CSST piping, such as black pipe, can be considered safely grounded if the appliance it supplies is hard-wired to the buildings electrical service (including ground) or plugged into a three prong, properly grounded electrical outlet.
4. Propane storage system: Integrity must be checked and repairs/replacement included with new installation. The propane storage system must be installed in accordance with the latest edition of NFPA 58.

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6.3 Additional Requirements Specific to Oil Systems

6.3.1 Installation

1. Chimney and connectors to be properly sized using latest edition of Standard for the Installation of Oil-Burning Equipment (NFPA31) and manufacturer's specifications. Oil venting systems must have a barometric damper installed and must not use side wall “engineered” power vent systems unless specifically allowed by the manufacturer’s specifications. Barometric dampers must be installed in a location specified by the manufacturer.
2. All oil piping to be leak-free and must be sized to provide adequate oil supply to all connected oil appliances. Oil line piping design, materials, and construction must be in accordance with the latest edition of NFPA 31. Refer also to the instruction manuals provided with the burner and oil pump. Fuel line piping must be airtight. Use only listed flare type fittings. Piping must be substantially supported and protected against physical damage and corrosion where required. Inspect existing fill, vent, oil tanks, filters and fuel lines for leaks, kinks and proper material support. Repair or replace as needed. All new and existing buried lines (in the floor) and unprotected oil lines on the floor must be encased in protective sleeve. Install one fuel shut-off valve near the storage tank and second fuel shut-off valve near the oil burner fuel pump. All systems must have a new oil filter installed. Note: NFPA 31 requires shut-off valves at tank and burners, also they both need to be Fusible Fire Safety Valves.
3. The integrity of the fuel oil storage system must be checked and repairs/replacement included with new installation. New oil storage system must be installed in accordance with the latest edition of NFPA 31.
4. Oil to Gas conversion: Refer to latest edition of the NFPA 31 “Abandonment and Removal from Service of Tanks and Related Equipment.”
5. ○*OPTIONAL BEST PRACTICE*○ It is recommended to have an anti-siphon valve located at the tank when the tank or oil line is above or level with the oil burning appliances. Anti-siphon Valve commonly referred to as “oil safety valve” or OSV are valves that operate with the use of a diaphragm that requires a minimum suction draw from the pump at the appliance before fuel is allowed to pass through it. Without a sufficient vacuum draw from the pump, oil cannot free flow from the tank by the siphoning action of a broken line. Follow manufactures installation instructions. If the oil supply line is in protective sleeve typically no Anti-siphon Valve is recommended.
6. ○*OPTIONAL BEST PRACTICE*○ Recommend that the customer keep the tank full during the summer to prevent condensation of moisture on the inside surface of the tank.

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6.4 Additional Requirements Specific to Furnaces

1. When installing a complete duct system, or a partial duct system that includes 25% or more of the duct system, the contractor must complete a duct sizing comparison using the latest version of ACCA Manual-D. Ducts must be designed to limit friction losses. Room by room load calculations must be performed for all new ductwork installations.

2. Ducted systems must have air filters installed in the return air system in a location that facilitates easy replacement by the homeowner. Filter slots must have a durable gasketed cover that seals tightly when in place and be enclosed in such a manner as to prohibit duct leakage at the filter slot opening, which reduces the effectiveness of the return air system, and may draw pollutants from the basement. All return air must pass through the return air filter.
3. All new duct systems installed must include minimum MERV 6 with design accounting for filter pressure drop at design airflow.

   ○*OPTIONAL BEST PRACTICE*○ Installing l minimum MERV 6 filter when replacing existing furnace only (no new ductwork installed). If doing so, manufacturer's minimum or higher airflow must be maintained for both heating and cooling modes.

4. Two or more units must not be connected in parallel or series to a common supply or return air duct system.
5. See also "Ductwork", Section 6.15, below.

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6.5 Additional Requirements Specific to Hot Water Boilers

6.5.1 Materials

1. As an alternative to Manual-J, IBR load calculations or an approved equivalent may be used.
2. New installed radiation must be sized using Manual J, IBR or approved equivalent.
3. Boiler, pump and system piping must be sized per manufacturer's specifications, IBR or approved equivalent.
4. Antifreeze: If used, a tag must be left on the system identifying the chemical type of the heat transfer fluid, its volume and concentration, and the date it was installed. Use only manufacturer's approved antifreeze that is also compatible with materials of construction.

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6.5.2 Installation

1. The contractor must ensure that the following boiler controls/piping are in place, working correctly, and conform to manufacturer's specifications:
   - Circulator
   - Air Elimination System
   - Water Expansion System: Hot water boilers must be provided with expansion tanks. Non-pressurized expansion tanks must be removed and replaced with a diaphragm expansion tank.
   - Pressure Reducing Valve (Fill Valve)
   - Low Water Cut Off
   - Safety Relief Valve

- Back-flow Preventer installed in domestic water line to boiler, if not already present and functioning correctly.
- Flow Control Valve (under some conditions)
- Isolation Valves
- Drain Valve
- High Limit Aquastat
- Pressure/Temperature Gauge

2. Controls and/or piping must be designed and installed to protect the boiler from thermal shock and low return water temperatures (per manufacturer's specifications).
3. Boiler and system piping must prevent oxygen contamination of boiler water and frequent water additions. Boiler and system must be leak-free. All water leaks, including pre-existing leaks, must be identified and repaired.
4. A raw water analysis must be taken initially for each installation so that the correct water treatment can be established and installed per manufacturer's recommendations. The primary goal of boiler water treatment is to control solids that cause deposits in the boiler and control gases that cause corrosion.
5. All piping, valves, fittings, insulation and connections must be rated for use at the operating temperature and pressure of the hydronic system. Existing pipe, fittings, valves or other materials must be free of foreign materials.
6. Boiler piping installed in unconditioned spaces (i.e., spaces outside of the thermal boundary of the dwelling) must be insulated with a minimum of R-4.

   ○*OPTIONAL BEST PRACTICE*○ Insulate existing boiler piping in unconditioned spaces to a minimum of R-4, unless doing so would create a risk of freezing water pipes in the space.

7. Piping must be installed so that piping, connections and equipment must not be subjected to excessive strains or stresses. Provisions must be made to compensate for expansion, contraction, shrinkage and structural settlement. Piping must include all necessary fittings, valves and piping for manufactures specified maintenance and cleaning.
8. All existing piping and radiation must be properly flushed to remove any sediment/sludge in order to prevent any blockage or reduction in efficiency of the new boiler.
9. When making changes to a distribution system involving piping, pipes, or valves, including installing a new circulator, the contractor must ensure proper Gallons Per Minute (GPM) flow through boiler and all radiation, with the ability to balance radiation as needed.
10. Two or more boilers installed: Controls and piping per manufacturer recommendations, which will provide the most efficient operation while meeting the heating and if added domestic water heater needs.
11. Open expansion tanks must be replaced with sealed and pressurized expansion tanks.

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6.6 Additional Requirements Specific to Combination or Condensing Boilers

6.6.1 Materials

1. All systems must have a minimum manufacturer rating AFUE or CAFUE > 90%.
2. ECM fan motors and water pumps must be installed on all equipment.
3. All systems must be sealed combustion.

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6.6.2 Installation

1. Unit must be designed and installed to operate in condensing mode in both heating and domestic water heating operation. Outdoor temperature reset controls must be installed if the existing radiation/radiators cannot meet the peak heating requirement with a return temperature of 130°F. The outdoor temperature reset controls must be commissioned to provide the lowest possible return water temperature while meeting the space temperature set point(s).
2. System must segregate heating function from domestic hot water production, with priority to hot water production.
3. ○*OPTIONAL BEST PRACTICE*○ Unit sizing, operation and radiation should be sized and setup to maximize condensing mode operation, with return water design typically not exceeding 130°F when possible.
4. ○*OPTIONAL BEST PRACTICE*○ Flushing and cleansing is important when installing a condensing boiler in existing systems with ferrous piping and/or radiation to ensure iron oxide, sludge, sediment and other dissolved contaminants do not foul the new boiler's heat exchanger. Prior to removing the existing boiler inject system cleaner and circulate at normal operating temperature for a minimum of 2 hours and up to one week. Drain and flush the system thoroughly at least twice, until the water runs clear. Once the new boiler is installed, filled and purged, inject system water treatment as recommended by the manufacturer. Consider installing in-line filters to remove contaminants from the system and safeguard the boiler's heat exchanger.
5. ○*OPTIONAL BEST PRACTICE*○ To provide the best opportunity for these installations to maximize the condensing feature, the following are recommended:
    - Unit should have self-modulating control capabilities.
    - All circulators should be variable speed and be able to module according to boiler fuel modulation. Circulators should have displays showing flow rate and energy consumption which are particularly useful during commissioning to optimize performance and ensure design conditions are being met.

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6.7 Additional Requirements Specific to Steam Boilers

1. Steam boiler to be sized using existing radiation: Sq. ft. of "Equivalent Direct Radiator" (EDR). Base the size of the replacement boiler on the connected load, not the building's heat loss.
2. A raw water analysis must be taken initially for each installation so that the correct water treatment can be established and installed per manufacturer's recommendations. The primary goal of boiler water treatment is to control solids that cause deposits in the boiler and control gases that cause corrosion.
3. New installed radiation must be sized using Manual J, IBR or approved equivalent.
4. The boiler must be checked for contaminants follow manufacture testing and recommendations.
5. Boiler piping and system piping must be sized per manufacturer's specifications, IBR or approved equivalent.
6. ○*OPTIONAL BEST PRACTICE*○ Determine if possible why the old boiler failed. Is there a possibility of buried (leaking) piping? Is there an issue with the condensate return time being too slow? Ask the homeowner/occupant the following:
   - Is there gurgling or banging noises in the pipes or radiators? Is the system radiation balanced?
   - Do they have to add water to the existing boiler, is the low water cutoff activated frequently, how often?

   Note these concerns and suggest remedies.
7. ○*OPTIONAL BEST PRACTICE*○ The contractor should review heating performance of all radiation with customer and note any rooms that are under or overheating. If this is noted the contractor should evaluate the need to add or remove radiation or correct radiation deficiencies. If air sealing and or insulation is part of the workscope the contractor should also evaluate the need to adjust radiation. Additional measures to consider include replacing radiator vents, adding or upgrading mainline air vents, insulating all steam pipes to keep the steam from condensing before it reaches the radiators.

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6.7.1 Installation

1. Boiler and system piping must prevent oxygen contamination of boiler water and frequent water additions. Boiler and system must be leak-free. All steam and water leaks must be identified and repaired.
2. All existing piping and radiation must be properly flushed to remove any sediment/sludge in order to prevent any blockage or reduction in efficiency of the new boiler. Refer to manufacturer's recommendations.
3. Piping must be installed so that piping, connections and equipment must not be subjected to excessive strains or stresses, and that any air pockets that may result in knocking noises or vibrations are eliminated. Provisions must be made to compensate for expansion, contraction, shrinkage and structural settlement. Piping must include all necessary fittings, valves and piping for manufactures specified maintenance and cleaning.
4. Two or more boilers: Controls and piping per manufacturer recommendations, which will provide the most efficient operation while meeting thermostat set point**.**
5. Boiler controls/piping must conform to manufacturer's specifications. The contractor must ensure that the following items are in place and fully functional as part of the installation:

- Low Water Cut Off (LWCO)
- Relief Valve
- Sight Glass
- Drain Valve
- High Limit Pressure Control
- Pressure Gauge

6. All piping, valves, fittings, insulation and connections must be rated for use at the operating temperature and pressure of the steam system. Existing pipe, fittings, valves or other materials must be free of foreign materials.
7. Boiler piping installed in unconditioned spaces (i.e., spaces outside of the thermal boundary of the dwelling) must be insulated with a minimum of R-4.

   ○*OPTIONAL BEST PRACTICE*○ Uninsulated steam pipes in unconditioned or in semi-conditioned areas can negatively impact the performance of a steam system. When there are performance problems that may be the result of the lack of insulation with a steam distribution system, it is strongly recommended that a contractor encourage the customer to insulate any pre-existing steam pipes in these areas both for energy savings and system maintenance, unless insulation of these pipes may cause a risk of freezing water pipes in these areas.

8. Steam boiler installation must provide for dry steam to supply piping and radiation, along with providing adequate return of condensate to maintain steady boiler water level. Existing steam traps, steam vents, wet returns, condensate receiver and pipe insulation or need thereof, to be inspected with proposal to install/repair as needed.
9. "Near Boiler Piping" is crucial for proper performance of a replacement steam boiler and must always be considered as part of the boiler installation. Always be sure to include clean-out and skimming tees in the near boiler piping. These "Tees" are necessary for proper cleaning and servicing of the boiler.

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6.8 Air Source Heat Pumps (ASHPs)

6.8.1 General

All ASHPs installed through the Program must conform to the requirements of the NYSERDA Air Source Heat Pump Program:

https://www.nyserda.ny.gov/all-programs/programs/air-source-heat-pump-program

6.8.2 Additional Installation Requirements for ASHPs

1. Additional requirement, installation:

a. When an ASHP is installed to provide the only heating source in a house or zone, without backup or supplemental heat, the ASHP must be sized according to heating loads, using engineering specifications *at design conditions* (not based on nominal or "rated" capacity).
b. All penetrations through the shell of the dwelling created during installation must be sealed with insulating sealant/spray foam. Any insulation disturbed by installed line set must be returned to original (or better) condition.

2. ASHP controls/thermostats must be installed as follows:
    a. In the event that the original heating system will remain in the dwelling to serve as a supplemental heat source, the contractor must provide a control plan for the thermostats, in which the operation of the ASHP and any secondary or supplemental heating systems are coordinated in such a way as to offer the customer the best options for maximizing benefit from the ASHP.
    b. Thermostats must be placed on interior walls, away from direct sunlight, appliances, heating ducts, radiators, or drafty areas
    c. In larger spaces (> 150 ft2) a fixed, wall-mounted thermostat must be installed in a location that will be representative of the space the unit is serving. Set the installer controls so that the temperature is actually sensed at the thermostat, rather than in the air handler.
3. The contractors must provide customers with the following guidance:
    a. Appropriate settings for controls to ensure maximum benefit from the ASHP, including:
        i. ASHP thermostat use and programming, including explanations for setting such as "heat" "cool" and "auto".
        ii. Optimum interaction with controls for a central heating system, if one remains in the dwelling, and written guidance on how to maximize value of using ASHP for heating and avoid using central heating systems in mild weather.
        iii. How and whether the ASHP works more effectively if setback or if kept at steady temperature settings;
    b. Maintenance requirements
    c. The importance of keeping snow away from outdoor unit, especially in heavy snow or drifting conditions, and of maintaining air flow clearances around exterior equipment, especially if visual enclosure is contemplated.

4. Location of outdoor unit(s) should always be approved by the customer.
5. ○*OPTIONAL BEST PRACTICE*○ The location of the outside units should take into account the following:
    a. Outdoor units should be located in inconspicuous places, such as the rear of the building.
    b. Contractors should avoid noise-sensitive areas. Interview customer to assess both degree of sensitivity, and locations that might pose trouble. If mounting to the wall of the building, efforts should be taken to minimize the possibility of noise caused by vibration of the unit being transmitted into occupied areas of the home. Mount on foundation, ensure a non-sensitive area, or use a ground-mounted alternative.

6. ○*OPTIONAL BEST PRACTICE*○ Ductless system design

a. When possible, avoid using multiple oversized ductless units in a multi-zone configuration. Size indoor terminals carefully.
b. When room loads are too small for indoor terminals, consider using compact-ducted terminals to serve several rooms, or use single-zone systems for small zones to allow adequate capacity turn-down.

7. ○*OPTIONAL BEST PRACTICE*○ Ductless indoor units

a. When possible, install ductless heads 4-6 inches below ceiling, even if this is more than the manufacturer's minimum clearance.
b. In rooms with vaulted ceilings, install ductless heads so their lower surface is no more than 6-7 feet from the floor, to facilitate heating distribution and filter changes. Consider using floor-mount consoles in heating applications.

8. ○*OPTIONAL BEST PRACTICE*○ ASHP Ductwork

a. New duct work should be run within the thermal envelope of the dwelling whenever possible.
b. If duct work is installed in an attic or other unconditioned space: after air sealing and insulating ducts, additional insulation should be installed over the ducts to ensure coverage consistent with attic insulation levels over the conditioned space. Duct vapor barrier must have adequate R-value to the interior (duct side) to prevent condensation on the vapor barrier.

9. ○*OPTIONAL BEST PRACTICE*○
Consider installing a hard-wired surge suppressor at the service disconnect or breaker panel to help protect the heat pump circuit(s).

10. ○*OPTIONAL BEST PRACTICE*○ Follow Northeast Energy Efficiency Partnerships (NEEP) Guidelines:

- "Guide to Sizing & Selecting Air-Source Heat Pumps in Cold Climates"
- "Guide to Installing Air-Source Heat Pumps in Cold Climates"

available at the following link:

http://www.neep.org/initiatives/high-efficiency-products/air-source-heat-pumps/air-source-heat-pump-installer-resources

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6.9 Additional Installation Requirements for Air Conditioners, not including Air Source Heat Pumps

6.9.1 Materials

See Sections 6.1

6.9.2 Installation

1. Design and installation of the outdoor units should include elements as needed to prevent possible damage from animals including the protection of wiring.
2. Unit must be placed to allow for free air flow. The contractor must follow manufacturer's guidance on clearance from obstructions including walls, overhangs, protrusions and other features. The contractor must ensure that the outdoor unit does not interfere with view through or operation of any window or door.
3. Line set insulation: Refrigerant vapor (suction) lines must be continuously insulated and vapor sealed with a minimum thickness of 3/8 inch of foam rubber or equivalent, and all seams sealed.
4. If required by the manufacturer, insulation must cover entire line set length (both pipes) to avoid condensation and energy loss. Once insulated, the outdoor portion of line set must be protected with a rigid cover to avoid insulation damage and installed in a workmanlike manner with tightly connected joints. UV tape must be added as needed to ensure that any remaining exposed insulation is protected.
5. Line set penetrations into the dwelling should be made rodent-proof (e.g., with PVC sleeve and cap drilled to the size of the refrigerant lines.)
6. All penetrations through the shell of the dwelling must be sealed with insulating sealant/spray foam. Any insulation disturbed by installed line set must be returned to original (or better) condition.
7. Refrigerator tubing flair connections:
    a. The contractor must create new flare fittings as needed, using a flaring tool and measurement gauge appropriate to the applicable refrigerant and in accordance with manufacturer's instructions.
    b. The contractor must not reuse used manufacturer-provided tubing flares and fittings.
8. Refrigerant piping: Piping installed in the earth or below a concrete slab must be encased in conduit or a minimum of Schedule 40 polyvinyl chloride. The encasement diameter must be at least 3/4 inches greater than that of the tubing and its insulation. The casing must be laid in a straight line to permit removal or insertion of the piping and must terminate above the grade level. Split systems must, where feasible, use only new, appropriately insulated refrigerant line sets specified by the manufacturer and not in excess of 50 feet. The linear, one-way length of refrigerant piping between the two sections of split units must not exceed the maximum distance specified in the manufacturer's published literature. The compressor section where feasible must not be more than 20 feet above or below the indoor unit. Oil traps or double suction risers, as required by the equipment manufacturer must be provided for oil return. Refrigerant piping must be supported properly to prevent excessive sagging, movement, or vibration and limit lateral movement, but permit normal thermal expansion and contraction.

9. The contractor must ensure all refrigerant piping installed:
    a. Has the correct size line set on split systems.
    b. Has the properly sized liquid line filter drier, field or factory installed.
    c. Is brazed with a nitrogen purge in the line set and indoor coil.
    d. Has a vacuum of 500 microns or manufacture specified microns drawn before releasing the factory charge, with no leaks.
10. The condensate must be properly piped, pitched, sized and insulated per manufacturer's specifications. Condensate must not terminate over walkways where accumulating/not draining properly condensate could damage building components. A secondary AC condensate drain must be installed with a drain pan to a conspicuous point of disposal, both AC condensate drains (primary and secondary) must discharge in different locations and the secondary drain to some easily accessible / conspicuous location that would alert the homeowner to the drainage issue. In cases where no secondary drain and no means of installing an auxiliary drip pan can be plumbed /installed to some conspicuous location, an interlocked detector / cutout switch must be installed so that outdoor unit is disabled if water level rises and activates detector / switch. The primary AC condensate discharge pipe must have a trap installation or per manufacturer's specification (no traps on a drip pan secondary line). If a condensate pump is installed, it must also have an interlocked detector / cutout switch be installed so that outdoor unit is disabled if water level rises and activates detector / switch.
11. Equipment must meet all manufacturer specified minimum clearances. Indoor equipment must have properly installed condensate line that is trapped and insulated. Indoor equipment must have a drip pan that extends under the entire unit.
12. Outdoor equipment must be placed on level concrete pad or equivalent. If mounting to the wall of the building, efforts should be taken to minimize the possibility of noise caused by vibration of the unit being transmitted into occupied areas of the home.
13. When possible, the contractor must avoid installing outdoor unit(s) directly under any drip line from the roof or other overhang that would subject them to falling snowmelt, ice or concentrated rain runoff, including roof valleys, or any roof without a gutter. When this is unavoidable, outdoor units must be installed with drip caps or shields approved by the manufacturer.
14. If the unit does not have a fuse to protect the unit's sensitive electronics, a surge protection must be installed per manufacturer specification or at the service.
15. The contractor must follow manufacturer allowed clearances for multiple units and avoid stacking units above each other except when explicitly permitted by manufacturer.
16. Outdoor units should be located in inconspicuous places for aesthetic and noise considerations.
17. Contractors should avoid noise-sensitive areas.

    ○*OPTIONAL BEST PRACTICE*○ Interview customer to assess both degree of sensitivity, and locations that might pose trouble.

    Transmitted noise from wall brackets is generally a minimal issue for 2x6 or thicker walls, and/or walls with 1inch+ rigid insulation. With 2x4 walls it's important to ensure a non-sensitive area, or a ground-mounted alternative.
18. Location of outdoor unit(s) should always be approved by the customer.

19. The replacement of the indoor units should take into account the following recommendations:
    a. Indoor wall mounted units should be installed high on the wall but with adequate clearance from the ceiling (a minimum of 12-18 inches) if possible for ceiling heights up to 8 feet. In rooms with higher or vaulted ceilings, they should be no higher than 8 feet. This will help focus the space conditioning on the occupied space in and cooling seasons.
    b. Equipment must meet all manufacturer specified minimum clearances.
20. Metering Devices: Equipment must have a TXV or electronic equivalent refrigerant metering device installed.
21. System charge must be checked by any method approved and specifically documented by the manufacturer that will ensure proper refrigerant charging of the system. Note: If outdoor conditions require a follow-up visit to finalize the charging process, this must be recorded at both the initial visit and the follow-up visit.
22. Accessories: All accessories must be designed and installed per manufacturer's specifications.
23. Service Access: All units must be located to allow service access for removal of any unit component without removing any piping, ductwork, or other permanently installed fixtures or components.
24. Two or more systems must not be connected in parallel to a common supply or return system.
25. All ducted Air Conditioning units must include a filter system with a minimum rating of MERV 6 unless otherwise specified in the manufacturer's specifications.
26. Start-up and Commissioning: The contractor must secure, in an easily visible location, a sticker showing their name, regular phone number, emergency service phone number (if applicable), and date of system startup. There must be, either in the owner's possession or affixed near the unit, all installation and operating manuals and warranties, and the contractor or his / her representative must instruct the owner on the complete operation of the heat pump system at the time of system startup. The contractor must conduct and provide start-up and commissioning report per manufacturer's protocol.

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6.10 Ground Source Heat Pumps

All contractors installing Ground Source Heat Pumps must meet the certification and installation requirements of NYSERDA's Ground Source Heat Pump Rebate Program. Requirements can be found at:

https://portal.nyserda.ny.gov/servlet/servlet.FileDownload?file=00Pt0000003HRiBEAW

6.11 Solid Fuel Burning Appliances (Woodstoves and Pellet Stoves)

6.11.1 Materials

1. Installed appliances must have a flue properly sized to the appliance that has the necessary vertical rise, is protected from extreme cold and is correctly configured according to the manufacturer's specifications.
2. ○*OPTIONAL BEST PRACTICE*○ Install sealed combustion units.

3. ○*OPTIONAL BEST PRACTICE*○ Ensure sizing of stove is based on BTU output figures from the list of certified EPA stoves, not from manufacturer promotional materials. Manufacturer promotional materials often have higher BTU figures than the EPA list of certified stoves, leading to an under sizing of appliances for the space intended to be heated.

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6.11.2 Installation

1. Installer must ensure that installed appliance and venting system are compatible and installed to manufacturer's specifications.
2. All combustion gas venting must be run to the exterior of the building and must terminate with an approved end cap. The contractor must ensure that venting conforms to manufacturer's recommendations and NFPA 211. As required, the venting system must extend at least 3 feet above the roof at its exit point, and at least 2 feet above any part of the roof within ten feet of the vent.
3. Vent piping should slope upward from the appliance at a minimum of ¼ inch/foot or according to manufacturer's specifications.
4. The contractor must ensure that the venting system is free from blockage or restriction, leakage, corrosion, inadequate vent connectors or other deficiencies that may cause an unsafe condition.
5. The contractor must ensure that appropriate clearances between the wood-burning appliance and combustible materials and the venting system and combustible materials are maintained as specified in the manufacturer's installation specifications.
6. Protection of combustible floors must be installed as part of the appliance install. Hearth boards or pads used to protect combustible materials in proximity to the appliance must be approved for such use.
7. Installed systems must have a dedicated combustion air intake. Whenever possible the system should be installed with a combustion air intake that is connected directly to outside air. The only exception to this installation is when the distance to outside combustion air and the associated angles of venting to the exterior, would exceed manufacturer's recommendations.
8. When a "skuttle" air intake is installed to bring in combustion air, this air intake must not be installed directly below the flue or on the windward side of the home, where during exceptionally cold days, the stove's emitted combustion byproducts from the flue/chimney, may be taken back into the fresh air of the household.
9. ○*OPTIONAL BEST PRACTICE*○ When installing a wood or pellet stove, the installer should also show the homeowner how to do recommended daily, weekly and/or monthly cleaning of the stove, including cleaning of heat exchanger. This demonstration may be one of the best ways to avoid future call backs and malfunctioning of the stove.

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6.12 Additional Requirements Specific to Wood Stoves

1. Installed appliances must meet Program guidelines for efficiency.
2. Installed appliances must be EPA Certified for particulate matter output of 4.5 grams per hour or less.

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6.13 Additional Requirements Specific to Pellet Stoves

6.13.1 Materials

1. Installed pellet stoves must be listed on the US EPA Certified Wood Stoves list as having a particulate matter output of 2.0 grams per hour (PM 2.0 g/h) or less and an actual measured efficiency of 70% efficient or greater.
2. Installed pellet stoves should be listed and labeled in accordance with ASTM E1509.
3. Pellet stove venting materials must be listed and labeled specifically for pellet stoves

6.13.2 Installation

1. Pellet stoves must be installed in accordance with ASTM E1509.
2. Flue lining and vent systems for use in masonry chimneys with pellet fuel-burning *appliances* shall be limited to the following:
   a. Flue lining systems complying with Section R1003.11.1 of the IRC (International Residential Code) 2015, or subsequent update.
   b. Pellet vents listed for installation within masonry chimneys per Section R1003.11.4of the IRC 2015, or subsequent update.

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6.14 Additional Requirements Specific to Domestic Hot Water Systems

6.14.1 General:

1. In 2017 the DOE changed testing procedures and rating standards for water heaters, which will affect how water heater efficiencies are labeled. This changes the efficiency listing from Energy Factor (EF) to Uniform Energy Factor (UEF). This new standard accurately reflects real-world use and pattern scenarios.
2. Water heaters installed through the Program must have a UEF that meets Program requirements.
3. The Air-conditioning, Heating and Refrigeration Institute (AHRI) has converted all DWH equipment from EF to UEF. The AHRI directory that lists UEFs for available water heaters is available at:

www.ahridirectory.org

4. Location: If possible, water heater must be placed where leakage from the relief valve, leakage from the related piping, or leakage from the tank or connections, will not result in damage to the surrounding areas, or to the lower floors of the building.
5. Drain Pan: A drain pan must be installed underneath the water heater if it is located where leaks could cause damage. A 1-inch line must be installed between the pan and an appropriate drain. A water alarm/shut-off can be installed in the pan if there is no place to run a drain line.
6. Leaks: Water heater and system must be leak-free. All water leaks must be identified and repaired.

7. If the water heater to be installed does not have factory-installed heat traps, the contractor may install heat traps or one-way valves, which allow water to flow into the tank and prevent unwanted hot-water flow out of the tank in both hot and cold lines.
8. Installation must include a shut off valve in the cold and hot water inlet / outlet lines. It must be located close to the water heater and be easily accessible. Use only full flow ball or gate valves.
9. Unions: Use dielectric unions or nipples to protect hot and cold water fittings from corrosion when connecting dissimilar materials such as copper and galvanized iron pipe.
10. Thermal Expansion Tank: If installing the water heater in a closed water system, install properly sized expansion tank. To clarify: thermal expansion of heated water may occur wherever potable water is heated in a closed system (when the potable water is isolated from the public water supply by a one-way valve, such as a pressure reducing valve, backflow preventer or check valve. Some water meters do have an internal check valve to protect the city mains from local contamination). Potable water expansion tanks are designed to absorb the increased volume of water created by thermal expansion and to maintain a balanced pressure throughout the potable water supply system. They are used to prevent plumbing system and/or water heater damage and unnecessary relief valve discharge caused by excessive pressure from thermal expansion.
11. T&P relief valve: Water heater must have the proper size and type T&P valve and discharge pipe installed per manufacturer's instructions.
12. Drain valve: Water heaters must have accessible drain valve installed.
13. Single-wall heat exchangers are permitted if they satisfy all of the following:
    a. The heat transfer medium is potable water or contains only substances which are recognized as safe by the U.S. Food and Drug Administration.
    b. The pressure of the heat transfer medium is maintained less than the normal minimum operating pressure of the potable water system.
    c. The equipment is permanently labeled to indicate that only additives recognized as safe by the FDA must be used in the heat transfer medium. Other heat exchanger designs may be permitted where approved by local code.
14. Well systems: If installed on private well systems, water heater must be able to operate correctly at the lowest anticipated operating water pressure.
15. Two or more water heaters: Controls and piping per manufacturer recommendations to provide the most efficient operation while meeting the hot water demands of the consumer.
16. Piping must be installed so that piping, connections and equipment must not be subjected to excessive strains or stresses. Provisions must be made to compensate for expansion, contraction, shrinkage and structural settlement. Piping must include all necessary fittings, valves and piping for manufactures specified maintenance and cleaning.
17. All installed fossil fuel fired DHW systems must be tested for combustion safety.
18. ○*OPTIONAL BEST PRACTICE*○ Insulate DHW supply pipes to improve delivery time and reduce heat loss to unconditioned or semi-conditioned spaces.

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6.14.2 Air Source Heat Pump Water Heaters

Materials

Installed systems must be ENERGY STAR ® rated.

Installation

1. Installed systems must be located outside of the conditioned area. Installed system must be located in space temperatures between 45-90 degrees. Or for a system that uses inlet air ducts: entering air must be between 40 – 90 degrees. Water heater location to be a 750 - 1,000 cubic feet of area or as required by manufacturer's specifications.
2. Heat Pump Water Heaters must have at the minimum the following modes of operation:
    - HEAT PUMP ONLY
    - HYBRID: This mode uses the heat pump as the primary heating source. The heating element will heat water if demand exceeds a predetermined level so that the set point temperature can be recovered more quickly.
    - ELECTRIC: The water heater functions as a conventional electric unit, relying totally on the elements to heat the water in the tank.
    - VACATION: Unit off or set for very low temperature

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6.14.3 Storage Water Heater

1. Storage water heater must be sized by peak-hour demand (the busiest one-hour), which can be determined by using GAMA Water Heater Sizing Tool. The water heaters First Hour Rating (FHR) must match within 1 - 5 gallons of peak-hour demand.

6.14.4 Indirect Storage Water Heater

Materials

Tank must be sized by peak-hour demand (the busiest one-hour), which can be determined by using GAMA Water Heater Sizing Tool. The water heaters First Hour Rating (FHR) must match within 1 - 5 gallons of peak-hour demand. In addition, the installed boiler output must meet the manufacturer's minimum Btu/hr. requirements to achieve First Hour Rating with the specified GPM through the Indirect coil at the design water temperature.

Installation

1. Indirect water heater must be piped as priority zone on boiler.
2. Boiler piping, controls and pumping must be installed to provide the proper flow through the indirect coil, specified by the indirect manufacturer.
3. Cold-start control strategy must be used.

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6.14.5 Tankless Water Heaters

Materials

1. Installed systems must be ENERGY STAR ® rated.
2. Must have a flow rate of at least .5 Gallons Per Minute (GPM).
3. Must have thermostatic control.
4. Two pipe systems or concentric pipe vented to the exterior, with an approved vent cap.
5. Sizing: Peak-hour demand (the busiest one-hour) flow rate, in GPM if possible measure the flow rate, (GPM) for each point of use, to determine how many gallons will be required during that peak demand time period flow rate in GPM, if not use GAMA Water Heater Sizing Tool to determine estimated peak-hour flow rate in GPM. Then determine temperature rise using coldest anticipated inlet water temperature and design outlet water temperature, the difference being the design temperature rise. Match peak-hour flow rate in GPM and anticipated temperature rise with manufacturer's rated flow rate in GPM and temperature rise.
6. System must be leak-free. All water leaks, including pre-existing, must be identified and repaired.
7. A raw water analysis must be taken initially of each installation so that the correct water treatment can be established and installed per manufacturer's recommendations. The treatment must be compatible with materials of construction. The primary goal of boiler water treatment is to control solids that cause deposits in the boiler and control gases that cause corrosion.

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6.15 Ductwork

6.15.1 General

1. Ducts must be assembled and installed in accordance with recognized industry practices to achieve air-tight and noiseless (no objectionable noise) systems, capable of performing each intended service.
2. Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8 inch misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable braces, and anchors of type which will hold ducts true-to-shape and to prevent buckling. Ducts must be braced and guyed to prevent lateral or horizontal swing. Installation must meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction. All installation must be in accordance with manufacturer’s published recommendations.
3. Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, the contractor must:
    a. Seal space between construction opening and duct or duct insulation with sheet metal flanges of same gage as duct.
    b. Overlap opening on 4 sides by at least 1½ inch.
    c. Fasten to duct and substrate.

4. Vapor Barriers: Where vapor barriers are present, the vapor barrier must be on the outside of ductwork. Vapor barrier must be unbroken. Joints, etc., must all be sealed. Where insulation with a vapor barrier terminates, it must be sealed off with the vapor barrier being continuous to the surface being insulated. Ends must not be left with exposed fiber glass or other insulation.
5. Return air must not be taken from any of the following locations; bathroom, kitchen, garage, crawl space, mechanical room or other separate dwelling unit. No supply ducts may be installed to the garage. New duct system must have return duct system installed. The use of building cavities in new duct system installations is not allowed. Return air path for each room must be provided by properly sized permanent means, such as return ducts, unclose-able grilled or louvered transfer into the door, wall or ceiling or undercut door with any combination thereof along with duct sealing and proper duct insulation as needed.
6. Fuel-burning Appliances: No duct system may be installed such that the sole source of return air is located in a room or space containing a fuel-burning appliance, except where the fuel-burning appliance is a direct-vent appliance.
7. Balancing Dampers: All newly installed duct systems must have balancing dampers installed for the purpose of air balancing the duct system with a means of access to balancing dampers.
8. Abandoned register, grilles and ductwork must be removed, blocked off and permanently sealed.
9. The contractor must check system balance and make modifications as needed to provide proper aiflow and room pressure. A system is considered balanced when room to room pressure differencial does not exceed 3 pascals when the system fan is running at design maximum speed.
10. Ductwork located outdoors: duct must be metal and installed with proper insulation resistant to UV, and ozone, acid rain, and physical elements produced from outdoor weather. Support members that connect directly to the ductwork are to be insulated with this same material. Horizontal ductwork located outdoors must be sloped at a minimum 2-degree angle to prevent the accumulation of water on top of the finished insulated duct.
11. Protection of Ducts: Ducts installed in locations where they are exposed to mechanical damage must have barriers to prevent such damage.
12. All new duct systems installed must include minimum MERV 6 with design accounting for filter pressure drop at design airflow.
13. Existing duct system airflow through the indoor unit, under steady state condition must be within ± 10% of the airflow required per the system design or manufacturer recommendations (with all accessories and system components in place). The contractor must measure airflow and adjust to above specifications.
14. On installation where a new duct system is installed the following must be met: The individual room airflows are within the greater of ± 20% or 25CFM of the design/application requirements for the supply and return ducts. The contractor must measure airflow and adjust to above specifications.
15. See Section 6.4 “Additional Requirements Specific to Furnaces” regarding filters.
16. ○*OPTIONAL BEST PRACTICE*○ When duct systems run through unconditioned space and are used for cooling only, register openings must be tightly sealed to prevent water vapor accumulation in the system during the heating season.

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6.16 Installation of Metal Ductwork

6.16.1 Materials

1. Metal ducts and plenums with a cross sectional area of 1.2 sq./ft. or less must be 30 equivalent galvanized sheet gage or thicker, over 1.2 sq./ft. must be 28 gauge equivalent galvanized sheet gage or thicker.
2. Duct liner material must be rated for its intended purpose and must not support the growth of fungus or bacteria.

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6.16.2 Installation

1. All joints and connections must be mechanically fastened with screws in three places.
2. Metal ducts must be supported by ½ inch wide 18-gage metal straps or 12-gage galvanized wire at intervals not exceeding 10 feet or other approved means.
3. Duct Liners must at minimum comply with the following:
    - All joints must be neatly butted. All rips and tears on the air stream surface must be repaired by coating damaged areas with approved adhesive or coating, or by replacement of duct liner.
    - Mechanical fasteners must be used to secure the duct liner to the sheet metal; these may be either impact-driven or weld-secured with adhesive that must be applied to the sheet metal with a minimum coverage of 90%.
    - Exposed edges must have adequate treatment to withstand operating velocities.
    - To avoid contact with liquid water, duct liner must be protected by use of a sheet metal sleeve and drip pan adjacent to such equipment as evaporative coolers, humidifiers, cooling coils, and outside air intakes.

6.17 Installation of Flex Duct

This section is extracted from the "Flexible Duct Performance and Installation Standards 3rd Edition" which is published by the Air Diffusion Council.

6.17.1 Materials

All tapes, mastics and non-metallic fasteners (plastic clamps) used for field installation of flexible ducts must be listed and labeled to UL 181B, with the proper shear strength and adhesion needed to stay effectively in place for the live of the HVAC system.

6.17.2 Installation

1. All connections, joints and splices must be made in accordance with the manufacturer's installation instructions.
2. Use the minimum length of flexible duct to make connections.

○*OPTIONAL BEST PRACTICE*○ It is recommended that flexible air duct branch takeoffs (run-outs), flexible air ducts direct to boots from the plenum and flexible ducts in radial duct systems be limited in length to 25 feet.

3. Flex ducts must not be installed where exposure to direct or indirect sunlight or UV producing air treatment devices can occur. Prolonged exposure to sunlight or UV light may cause degradation of the core material or the vapor barrier.
4. The contractor must repair torn or damaged vapor barrier/jacket with duct tapes listed and labeled to UL 181B; if internal core is penetrated, replace flexible duct or treat with a splice.
5. Ducts must be installed fully extended and not installed in the compressed state. Contractors must avoid installing excessive lengths where possible. Duct must be installed without any kinks or excessive bends.
6. Ducts must not be installed in concrete, buried below grade or in contact with the ground.
7. Ducts must not be installed near hot equipment (i.e. furnaces, boilers, steam pipes, etc.) that is above the recommended flexible duct use temperature.
8. Flexible duct must be supported at manufacturer's recommended intervals, but at no greater distance than 5 feet. Maximum permissible sag is ½ inch per foot of spacing between supports. Duct supported with "Zip" ties must not sag or kink.
9. Hanger or saddle material in contact with the flexible duct must be of sufficient width (minimum of 1 ½ inch) to prevent any restriction of the internal diameter of the duct when the weight of the supported section rests on the hanger. Individual ducts must be separately supported.
10. Flexible ducts may rest on ceiling joists or truss supports. Maximum spacing between supports must not exceed the maximum spacing per manufacturer's installation instructions.
11. Vertically installed duct must be stabilized by support straps at a maximum of 6 feet on center.

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6.18 Installation of Rigid Fibrous Duct

6.18.1 Materials

1. In an up-flow configuration, standard uncoated fibrous glass duct board may be used adjacent to the coil plenum.
2. For down-flow furnaces, sheet metal must be used directly below the unit and then for four feet in the ductwork adjacent to the coil plenum. Standard uncoated fibrous glass duct board may be used after the first four feet of coated duct.
3. In an up-flow configuration with a side return, standard uncoated fibrous glass duct board may be used in the return adjacent to the furnace fan.
4. In a horizontal supply system with a horizontal return, standard uncoated fibrous glass duct board may be used in the return adjacent to the furnace fan.
5. For up-flow furnaces with a bottom return, sheet metal must be used in the return ductwork directly below the unit. In addition, the return boot must also be fabricated from sheet metal to prevent any

water that may enter the system from collecting in the boot. From the return boot, standard uncoated fibrous glass duct board may be used for the rest of the return.

6. In a horizontal supply system, there are two options that may be considered. Metal duct, installed so that it slopes back to the condensate pan, may be used for the first four feet of duct adjacent to the coil. To prevent air infiltration, all seams and connections must be sealed with a UL 181 approved closure system. In addition, exterior insulation is to be used on the metal duct to prevent condensation potential. After four feet, the ductwork may be transitioned to standard uncoated fibrous glass duct board with all butt seams sealed with a UL 181 closure system. The other option is to use coated or laminated fibrous glass duct board adjacent to the coil. This ductwork must also be sloped back toward the furnace to prevent water from traveling through the duct system. As with the metal duct, all board edges of the fibrous glass duct board must be sealed with a UL 181 closure system prior to fabrication to reduce the surface area of the exposed edge.

6.18.2 Installation

1. Rigid fibrous glass duct must not be used in concrete, buried below grade, or any other location where it may be exposed to weather or physical abuse.
2. Rigid Fibrous Glass Duct must be made and installed using tools and/or machines designed for that purpose.
3. Hanger straps or saddles must be a minimum of 2 inches wide. Avoid sharp edges and burrs. Hangers must be spaced on 6 feet centers and must be located at circumferential joints wherever practical. Duct must be hung so that the hanger will not cut or otherwise damage the duct facing (NAIMA Fibrous Glass Duct Liner Standard).

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6.19 Duct Sealing

6.19.1 General

1. Duct sealing must be prioritized where the pressure is greatest (typically closest to the air handler) and then out toward the extremities of the system. Care must be taken when performing duct sealing to avoid exceeding manufacturer's rated temperature rise/drop across the heat exchanger of the furnace or CAC.
2. For energy savings, only ducts in unconditioned space must be sealed. Ducts in enclosed crawl spaces and basements have proven to have marginal payback. Therefore, it makes the most sense to seal ducts that are located in ventilated spaces or ambient areas such as ventilated attics, open crawl spaces, garages, etc. Once the decision is made to seal a duct segment, all the openings in the duct system must be sealed starting closest to the system air handler and moving toward supply and return registers.
3. ○*OPTIONAL BEST PRACTICE*○ In situations where a central humidifier exists in the furnace, the contractor must evaluate where leaks in the return ducts may create a pressure imbalance and drive moisture into unconditioned spaces, such as unconditioned attics or wall cavities. In these instances, sealing return ducts and thorough air sealing can be critical.

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6.19.2 Materials

1. Cork tape or equivalent must be used for sealing gaps where refrigerant and/or drain lines penetrate coil or plenum.
2. 181A or 181B metallic pressure tape with non-butyl (i.e. acrylic) adhesive must be used to seal service panels, access covers, etc.
3. Rigid Fibrous Glass Duct, Tapes and Mastic must comply with the following: UL 181A and must be marked “181 A-P” for pressure-sensitive tapes, “181 A-M” for mastic and “181 A-H for heat sensitive tape.
4. Flex, Metal to Metal Ducts Tapes and Mastic must comply with the following: UL181B and must be marked “181 B-FX for tape or “181 A-M” for mastic.
5. Consult manufacturers’ recommendations and ensure compliance with their requirements for installation, shelf life, and long-term storage of closure tapes and mastics.
6. 100% silicone caulk may be used at component to component and component to plenum connections.

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6.19.3 Installation

1. All joints, seams and connections of the duct system must be mechanically fastened with screws in at least three points. These joints, seams and connections must be sealed with duct mastic. **Photo:** Metal Ductwork Sealed with Mastic.
2. Surfaces to receive sealant must be clean, meaning free from oil, dust, dirt, rust, moisture, ice crystals, and other substances that inhibit or prevent bonding.
3. Cracks or seams wider than ¼ inch must to be repaired with fiberglass mesh as well as mastic.
4. Gaps over 1 inch wide must be repaired with a sleeve or sheet metal patch and sealed with approved mastic or tape.
5. Air handler access panels and seams that may need to be opened for service must be sealed with a UL181 rated tape.
6. Connections between the air handler and the cooling coil or hot water coil must be sealed with 100% silicone caulk. **Photo:** Air Handler Sealed with Silicone Caulk.
7. Flex duct connections must be made with hard duct connectors, held in place with a vinyl tension strap and the strap screwed into place. The connection between the inner liner and the hard duct that it is connected to must be sealed with duct mastic.
8. Boot to floor, wall or ceiling connections for supplies and returns must be mechanically fastened to the surface or surrounding framing and sealed to the wallboard or subfloor with mastic.
9. If there is a filter door, it must have an operable door that closes securely and is reasonably tight.

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6.20 Duct Insulation

6.20.1 General

1. Insulate any sections of duct systems that are in unconditioned spaces to code levels.
2. Duct sealing must take place before insulating ducts.
3. Air conditioning ducts in unconditioned spaces must have a continuous Class I vapor retarder to avoid condensation and water damage. The seams of the vapor retarder must be sealed with vinyl tape. The entire duct system in the unconditioned space must be insulated. Special attention must be paid to ducts that run near the roof sheathing in cold climates. Failure to seal ducts in this area can lead directly to ice damming.

6.20.2 Materials

1. Vinyl duct wrap with a minimum R-value of 6 must be used to insulate ducts in unconditioned basements, crawl spaces, or garages.
2. Vinyl duct wrap with a minimum R-value of 8 must be used in unconditioned attics.
3. Vinyl Tape made especially for use on vinyl duct insulation
4. Clamp stapler and staples must be used to secure ducts
5. Materials must be resistant to UV, and ozone, acid rain, and physical elements produced from outdoor weather.

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6.20.3 Installation

1. Duct insulation must be installed by wrapping insulation around ductwork and attaching neatly using a clamp stapler with staples every two inches. Two inches must be added to the width of the duct wrap to provide the excess wrap needed to create a neat tight seam that can be stapled without compressing the insulation. Do not pull the insulation too tight as this will compress it and decrease its R-value.
2. No fiberglass must be left exposed. All seams and tears in the vinyl vapor retarder must be sealed using vinyl tape. **Photo:** Sealed Vapor Retarder on Attic Ductwork.
3. No part of the duct system must be left un-insulated, including supply and return boots. When insulating cooling system ducts, the vapor retarder must be made continuous.
4. If floor joist bays are used as return ducts and are to be insulated, the contractor must first ensure that all leakage paths into the bays are sealed. Duct insulation must then be wrapped around 3 sides and stapled near the top of each joist or to the subfloor on each side. Duct insulation must be in substantial contact with all sides of duct area. Seams must be mechanically reinforced using vinyl tape.

7. Controls

7.1 Programmable and Smart Thermostats

7.1.1 Materials

1. All installed thermostats must be compatible with the equipment they are controlling.
2. The thermostat must have a minimum of a 5/2-day program schedule.
3. The thermostat must be easy to program and maintain by the customer. The display screen must be easily readable, and appropriate for the visual capabilities of the customer.
4. ○*OPTIONAL BEST PRACTICE*○ A large display and touch screen programming will aid setup.
5. In situations where a customer may use a furnace fan as a cooling system, the thermostat must have a "Fan On" switch.

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7.1.2 Installation

1. The thermostat must be installed according to the manufacturer's specifications and instructions.
2. Installed thermostats must be properly leveled, calibrated as specified by the equipment manufacturer and appropriately located:
    a. On an interior wall
    b. Out of the path of direct sunlight
    c. At an appropriate distance from heat sources, such as incandescent lights, heat vents or radiators.
3. The surrounding finish surfaces must be returned to the same condition as pre-installation.
4. After installation the thermostat must be turned on and the program must be verified.
5. The contractor must leave the program instruction manual with the homeowner and must verbally walk through the process for programing the thermostat.
6. Heat Pump Thermostats: In no case (for normal heat pump operation) must the auxiliary heater(s) be wired to energize during the first heating stage of the indoor thermostat. Either a manual emergency heat switch on the sub base, or automatic controls (factory installed) within the heat pump must be supplied to allow all of the auxiliary electric heaters to be electrically turned on during the heating season (under control of the indoor thermostat but with the compressor and outdoor thermostats bypassed) for use when the heat pump compressor or associated refrigeration equipment is inoperative. An outdoor thermostat, intelligent thermostat (two-stage) or equivalent control may be used to lock out the supplemental heat when outdoor temperature is above the thermal balance point.
7. The contractor must collect and properly dispose of the thermostat being replaced. Special attention must be paid to the proper disposal of thermostats containing mercury. All mercury thermostats must be disposed of according to the NYS Mercury Thermostat Collection Act. Thermostat wholesalers may serve as disposal sites.

7.2 Boiler Outdoor Reset Controls

7.2.1 General

While all boilers can show savings when combined with outdoor reset control, not all existing boilers are good candidates for this control strategy. The boiler reset control must only be installed under the following conditions:

- The boiler is in good working order, with venting system in good condition.
- If a combustion efficiency testing is conducted the results indicate 75% or higher combustion efficiency.
- No tankless coil is in use on the boiler
- Programmable thermostat setbacks are limited to 5 degrees or less
- Annual heating usage exceeds 50 million BTUs, as per chart below:

Table 6. Annual Heating usage

Annual Heating Usage	Fuel Type
500 Therms	Natural Gas
535 Gallons	Propane
350 Gallons	# 2 Fuel Oil

7.2.2 Material Requirements

Control and all materials installed must be compatible with equipment that it will be installed with.

7.2.3 Installation Requirements

1. All installed equipment must be installed in compliance with state and local codes.
2. All equipment must be installed in accordance with manufacturer's specifications.

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7.3 Time of Use Timers for Electric Hot Water Tanks

Time of use timers for hot water heaters may be eligible for installation if the water is heated by electricity and the household has time of use (or on-peak/off-peak) rates. If time-of-use rates are in effect, or available the contractor must ensure that household is switched over to these rates as part of the process. The following conditions must be met:

1. Water is heated by electricity
2. The household must have time of use (or on-peak/off-peak) rates. If time-of-use rates are in effect, or the contractor must ensure that household has switched over to these rates as part of the process
3. Water tank must have an 80-gallon capacity or greater
4. Timer to be installed must have a battery backup
5. Written permission has been obtained by owner, and timer and rates must be acceptable to household

6. The contractor must ensure that household must be willing and capable of adjusting the timer and replacing the batteries as needed and is educated by the contractor on the use of the timer.

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8. Lighting

8.1 LEDs

8.1.1 Material

1. ENERGY STAR ® rated
2. Operable in enclosed lighting fixtures.
3. If installed outdoor, operable in year-round exterior temperature conditions.
4. All socket extenders installed must be UL listed.
5. Color rendition must be acceptable to the family and appropriate for their needs.

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8.1.2 Installation

1. Replacement must be guided by customer usage, with priority given to high-use lighting. Pre-existing bulbs must be determined to have at least a two hour per day burn time.
2. Installation should not be undertaken if there is a reasonable concern of damage to a fragile or poorly installed fixture.
3. Do not install LEDs in locations that have a high potential for breakage.
4. LEDs replacement must reasonably match the lumen rating of the replaced bulb, unless directed by occupant to install bulbs with different lumen output.
5. Only bulbs marked as “dimmable” can be used with a dimmer light control.
6. After installation turn on light and verify that bulb energizes and comes to full brightness.
7. The contractor must install or assist household in installation of all lighting provided by the contractor prior to invoicing the Program.
8. LEDs must not be installed to replace a CFL.
9. Socket must be functional, and no hazardous conditions exist.
10. All replaced incandescent bulbs must be removed from the premises and disposed of properly.
11. Any LEDs damaged during installation must also be disposed of properly.
12. ○*OPTIONAL BEST PRACTICE*○ Motion sensor timers can be installed on exterior lighting fixtures. The installed sensor should be tested to ensure that it energizes the fixture only when there is activity in the desired area.
13. ○*OPTIONAL BEST PRACTICE*○ During the lighting installation the contractor should also look for opportunities to downsize existing lighting, such as reducing the number of bulbs used.

8.2 Lighting Fixtures

8.2.1 Material Requirements

All installed fixtures must be ENERGY STAR® rated.

8.2.2 Installation Requirements

1. The fixture must be installed according to all local electric codes.
2. If the contractor determines that the existing wiring condition is inadequate or that replacement will result in damage to the home, the installation must not go forward.
3. ○*OPTIONAL BEST PRACTICE*○ If the fixture bulb is of a custom design, a spare bulb should be left with the customer for each installed fixture.

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8.3 LED Nightlights

8.3.1 Material Requirements

Must be photocell operated.

8.3.2 Installation Requirements

If installed as an energy efficiency measure, must be installed to replace an incandescent light that is currently left on at night.

8.4 Torchieres

8.4.1 Material Requirements

Halogen Torchieres must be replaced with ENERGY STAR ® LED models of comparable luminescence.

8.4.2 Installation Requirements

1. The contractor must install lighting of comparable or higher luminescence.
2. Unless rated as dimmable, torchieres must not be installed in a light fixture operated by a dimmer.
3. If a new torchiere is installed during the visit, the old torchiere must be disabled by removing and disposing of the old bulb and cutting the power cord. The contractor may leave the old halogen torchiere for disposal by the household.

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9. Hot Water Efficiency Measures

9.1 Showerheads

9.1.1 Material

1. Installed showerheads must have a maximum flow rating no greater than 1.5 gpm (gallons per minute).
2. Showerhead must be acceptable to the household.

○*OPTIONAL BEST PRACTICE*○ The water flow can be simply and quickly measured with a plastic gallon milk jug with a hole cut out of the top that fits the shower head. If the gallon just fills in 20 seconds or less, the showerhead has a flow rate of 3 gpm or greater (20 seconds x 3 = 1 minute)

○*OPTIONAL BEST PRACTICE*○ Replace a standard showerhead with a showerhead with hand-held capabilities. Customers may be more receptive to the new showerhead because it represents an enhancement.

9.1.2 Installation

1. Inspect the existing pipe connector section for weakness due to corrosion and do not change if pipe is obviously weakened.
2. Showerhead must be installed without causing damage, including cosmetic damage, to the plumbing. ○*OPTIONAL BEST PRACTICE*○ for installation*:*
    a. Grasp the pipe connector firmly and use slip joint pliers/channel locks to remove existing showerhead
    b. Do not use excessive force. Bear in mind that the installer or installing company is financially liable for repairs.
    c. Clean the threads of the pipe connector to remove old sealant tape or plumbing putty.
    d. Cut a six to eight-inch length of new sealant tape and wrap it around the threads of the pipe connector. Be sure to wrap the tape in a clockwise direction. Installed tape must be neat with no dangling or frayed edges showing.
    e. Hand tighten the new showerhead into place on the pipe connector.
    f. Use a rubber patch to protect the showerhead from the teeth of the slip joint pliers when tightening the shower head.
    g. Do not over tighten. The sealant tape will make the water tight seal without forcing the shower head on too tight.
    h. Turn on the shower and inspect for leaks. The water stream must be even and flow straight from the showerhead

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9.2 Faucet Aerators

9.2.1 Material

1. Flip faucet aerators must have a maximum rated flow of 2.0 gpm
2. Standard aerators must have a maximum rated flow of 1.0-1.5 gpm

9.2.2 Installation

1. Rated flow of existing aerator must be lower than replacement aerator. ○*OPTIONAL BEST PRACTICE*○ for installation:
   a. Remove the old aerator by turning in a counter clockwise direction.
   b. While no aerator is installed run the water for a few seconds to flush out debris.
   c. Cut a six to eight-inch length of new sealant tape and wrap it around the threads of the new aerator. Be sure to wrap the tape in a clockwise direction. The tape must be minimally visible and neatly installed with no dangling or frayed edges.
   d. Screw the new aerator into place finger tight and then further tighten a half turn with slip joint pliers/channel locks. Use a rubber patch to prevent damage to the new aerators finish
   e. Turn on the faucet and check for leaks.
   f. Check that the lever works correctly on the flip aerator and that the increased back pressure caused by stopping flow through the aerator with the lever does not cause the seal between the faucet and the aerator to leak.
2. As part of customer education, the home owner must be shown how the flip aerator works and given a few suggestions as to when it would be a useful feature.

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9.3 Domestic Hot Water Tank Wraps

9.3.1 Material

1. Tank wrap must be two-inch fiber glass backed by a vinyl covering.
2. "Cinch" staples must be ½ inch.

9.3.2 Installation

1. The contractor must ensure that there is no warning posted on the appliance that prohibits wrapping the tank.
2. Insulation must not be installed in a compressed state.
3. Pressure relief valve and pipe stub ins must not be covered by wrap. Insulation must be cut on three sides at location of control plate access panels to allow for access as needed.
4. All joints must be sealed with vinyl or other tape that ensures a permanent, secure seal.
5. Wrap must be secured to the tank with staples, baling wire or other means that ensure that the wrap remains in place for the life of the tank.

6. ○*OPTIONAL BEST PRACTICE*○ for installation:
    a. Measure the diameter of the tank and add four inches to it. Then use the adjusted diameter (d) to calculate the tank insulation length around the tank circumference (C) using this formula: C=π times the diameter. OR: wrap a tape measure around the tank.
    b. Cut the tank wrap to length C + 2 inches and insulate the side of the tank. Do not pull the tank wrap so tight that it compresses the insulation.
    c. Use the excess two inches from the tank wrap length that was cut to fold the tank wrap at the seam and neatly staple it together every two inches with a cinch stapler.
    d. If it is power vented or an electric tank, cut a circular piece of tank wrap that has a diameter two inches greater than the tank. Cut a second piece of tank wrap that is the same diameter of the tank and place that on top of the tank. Place the round section that is 2 inches greater in diameter on top of the tank and using the excess wrap, fold the edges of the side wrap and the top wrap together and fasten securely with the cinch stapler every two inches.

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9.4 DHW Pipe Insulation

9.4.1 Materials

1. Installed pipe insulation must be neoprene or closed-cell foam material of at least ½ inch thickness.
2. Seams must be sealed with suitable material to ensure a permanent firm seal. Acceptable materials include, but are not limited to:
    a. Nylon cable ties ("zip" ties)
    b. Electrical tape

9.4.2 Installation

1. The first three feet of hot water pipe exiting from the DHW tank must be insulated with ½ inch pipe insulation,
2. The first three feet of cold water pipe exiting from the DHW tank must be insulated with ½ inch pipe insulation.
3. All elbows must have mitered corners.
4. “T” connections must have fish mouths cut int o make a tight joint.
5. Pipe insulation must be installed with the seam facing downward. And must be secured using nylon cable ties spaced no greater than 12 inches apart. Pieces longer than 6 inches must have a tie on each end. Ties must be cinched hand tight and must not cause compression of the insulation. The protruding end of the tie must be cut off.
6. Pipe wrap must not come within six inches of single wall flue pipe or within three inches of double wall or b-vent flue pipe on fossil-fuel fired hot water tanks.

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9.5 DHW Temperature Setback

Checking the hot water temperature and adjusting the temperature to meet the occupants' needs can result at energy savings with very little effort.

9.5.1 Installation

1. The contractor must measure and document hot water temperature at the fixture farthest from the hot water source. The fixture must be opened fully with only hot water running and be allowed to run long enough so that the hot water line is fully charged.
2. If the measured hot water temperature exceeds 120 degrees F, the contractor should recommend to the occupant that the water heater setting be lowered so that it delivers water at 120 F. Upon approval of occupant, the contractor may lower the water heater thermostat to achieve 120 F delivery temperatures and must document the new thermostat setting.

   ○*OPTIONAL BEST PRACTICE*○ After testing the water temperature, invite the customer to adjust the water to their preferred shower temperature. Once set, measure the temperature and show the customer. In many instances, customers who prefer a "really hot shower" find that they are using water at a temperature of around 108 degrees. This can be a real eye-opener when you are discussing temperature setbacks.

3. In the case of electric water heaters:
   a. Circuit breaker should be turned off prior to adjusting settings
   b. If the water heater contains two heating elements, both heating elements must be adjusted.
   c. The contractor must ensure that the circuit is turned back on upon completion of adjustment.
4. ○*OPTIONAL BEST PRACTICE*○ In the case of natural gas or propane water heaters, temperature settings are not typically identified on the dial. The contractor may mark the original setting, turn down the dial an estimated amount based on original temperature setting, and instruct the household member how to make further adjustments if necessary.
5. Note: Common water heater thermostats are not very accurate and the contractor will have limited ability to make a precise adjustment. It is not feasible to re-measure the outlet water temperature because the water heater will need to purge its existing contents and refill. The contractor must make their best attempt to set the thermostat to the correct lower temperature.

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10. Appliances

10.1 General Requirements

10.1.1 Material Requirements

All replacement appliances must be ENERGY STAR ® rated except where noted otherwise.

10.1.2 Installation Requirements

1. All replacement appliances must be installed in compliance with manufacturer's installation specifications.
2. Circuit must be safe after installation.

10.2 Additional Requirements Specific to Dryers

10.2.1 Material Requirements

Dryers that are installed through the program must have a sensor that turns off the dryer automatically when clothes are dry.

10.2.2 Installation Requirements

1. The contractor must evaluate the appropriateness of installation:
    a. Location must allow dryer to be vented to the outside without an extensive dryer duct run.
    b. Natural gas must be available to the location where the dryer is to be replaced.
    c. If the pre-existing dryer is electric, the proposed dryer is propane or natural gas, and there are indications that the house is very tight, adding another combustion appliance may not be advisable. In these cases, the contractor must contact the Program Implementer and discuss the option of blower-door testing to ensure safe installation.
2. Dryer installations must include metallic vent ducts (not vinyl).
3. CAZ and gas leak testing must be completed as required by BPI.

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10.3 Other Electric Reduction Measures

In evaluating options for reducing energy use, it is important that the contractor review household usage patterns to identify additional measures. Some examples are as follows:

1. Opportunity to reduce or eliminate electric space heater use by enhancing or repairing the main heating system's distribution system, air sealing or insulating.

2. Programmable thermostats may be installed in homes heated by electricity. See Section 7.1 for further information.
3. A motion sensor light or time for a high-wattage outdoor light that is currently left on all night.
4. Repairs to well pump systems that cycle continuously due to a leak in the system.
5. Insulation and air sealing to reduce or eliminate use of roof heat tape installed to counteract ice damming.
6. Leaking hot water pipes or faucets.
7. Provide timers for TVs or other appliances left to run continuously.

APPENDIX A: Example Pictures

Top Plates Sealed with 1-Part Foam (Click to Return to Section)

Dropped Soffit Sealed with XPS and 1-Part Foam (Click to Return to Section)

Knee Wall Transition Sealed with XPS and 1-Part Foam (Click to Return to Section)

Attic Hatch Weather-stripped (Click to Return to Section)

Pull Down Staircase Enclosure (Click to Return to Section)

Chimney in Attic Sealed with High-Temp Caulk and Metal Flashing (Click to Return to Section)

Bath Fan Sealed with 1-Part Foam (Click to Return to Section)

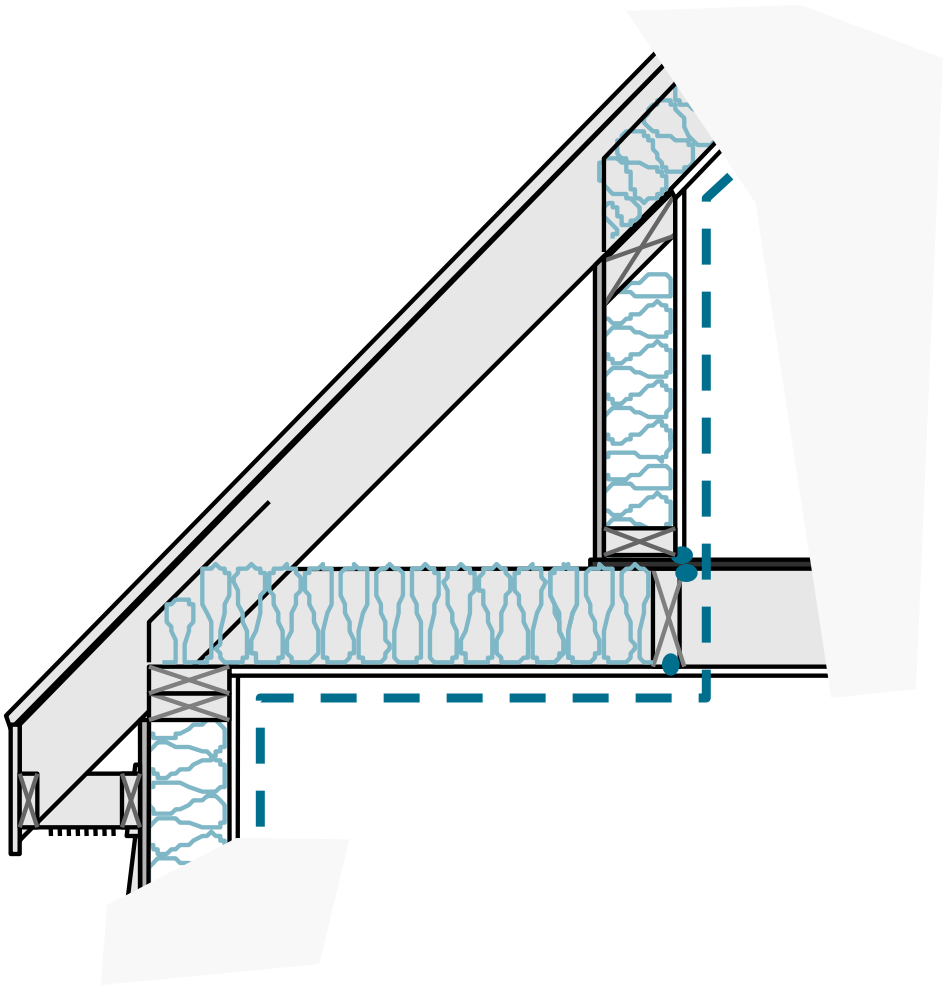
Open Attic Chase Sealed with Sheet Metal, Duct Mastic and Acoustical Sealant (Click to Return to Section)

Plumbing Wet Wall Sealed with Fiberglass Batt Backer and 1-Part Foam
(Click to Return to Section)

Ceiling Height Transition Wall Sealed with 2-Part Foam (Click to Return to Section)

Chimney in Basement Sealed with Sheet Metal and High-Temp Caulk (Click to Return to Section)

Kneewall Attic Air Sealed Along Rafter Line (attic space within thermal/pressure boundary) (Click to Return to Section)



Kneewall Attic Diagram for Air Sealing Along Wall/Floor Framing (attic space outside thermal/pressure boundary)

(Click to Return to Section)

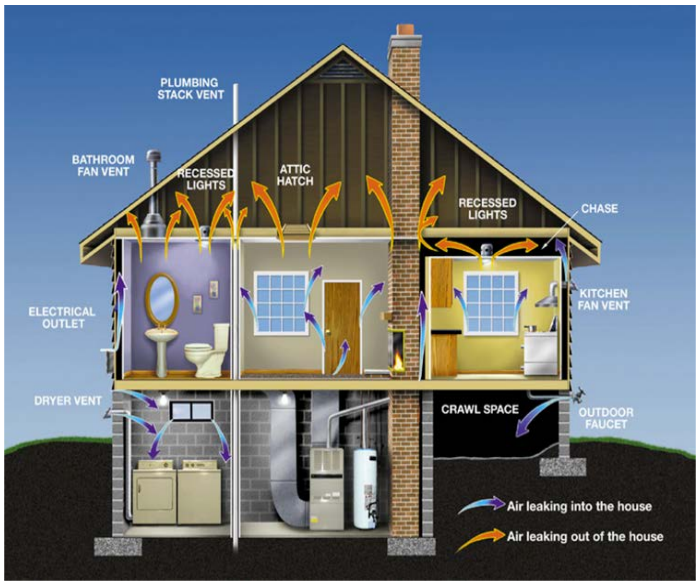
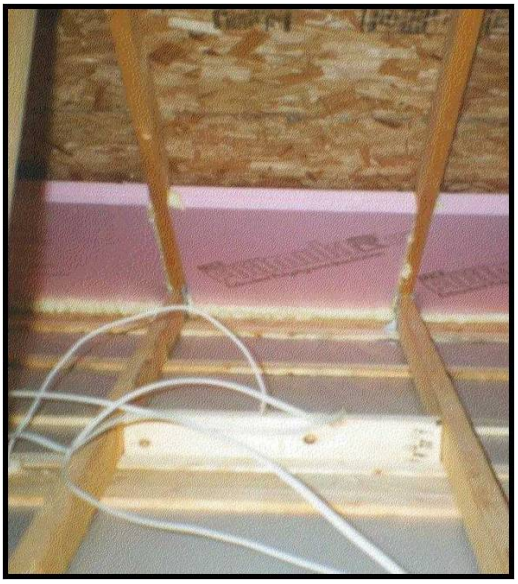


Diagram of General Air Leakage Paths (Click to Return to Section)



Insulation Wind Wash Baffle
(Click to Return to Section)

Loose Fill Attic Insulation Evenly Installed (Click to Return to Section)

Attic Insulation Dammed Away from Chimney (Click to Return to Section)

Smoke Testing Dense pack (Click to Return to Section)

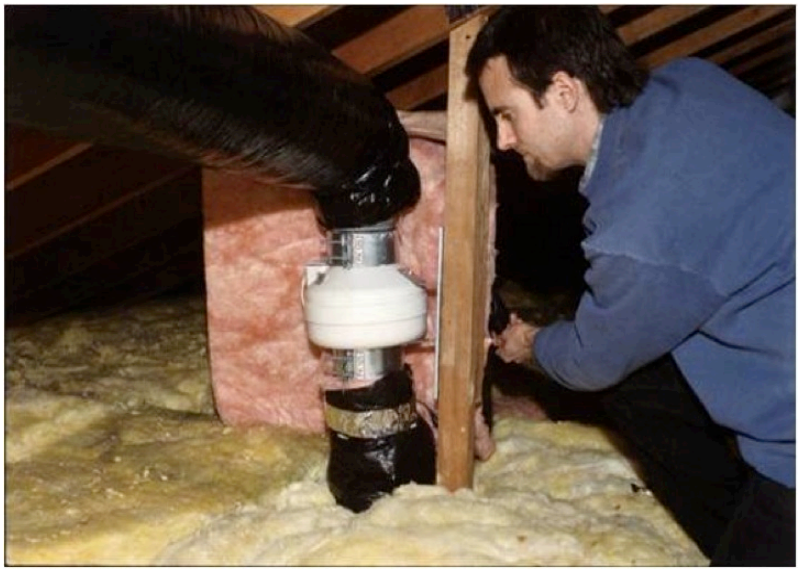
Crawlspace Ground Cover (Click to Return to Section)

Rim Joist Insulated (and Sealed to Sill) with Foam Board and 1-Part Foam (Click to Return to Section)

Metal Ductwork Sealed with Mastic (Click to Return to Section)

Air Handler Sealed with Silicone Caulk (Click to Return to Section)

Sealed Vapor Retarder on Attic Ductwork (Click to Return to Section)



In-line Exhaust Fan Ventilation (Click to Return to Section)

APPENDIX B: Spray-applied Polyurethane Foam (SPF)

B.1 Appendix Scope

1. This appendix applies to plural component polyurethane products.
2. High Pressure Polyurethane Foam systems are systems where the materials are generally delivered in unpressurized containers. Application equipment includes generators, compressors, pumps, heaters, heated hoses, and other associated equipment. Pressures used are usually between 800 and 1200 PSI on the hoses.
3. Low Pressure Polyurethane foam systems are application systems delivered in pressurized containers that require ambient conditions be acceptable for installation. There is no apparatus on these systems to heat them. The only auxiliary apparatus needed is a small non-heated hose and/or an application gun. Pressure on materials is below 30 psi.

B.2 General Requirements

1. All materials, products and equipment must be delivered, handled, stored, fabricated, assembled, installed and operated in accordance with the manufacturer's printed instructions.
2. Installation must comply with all federal, state and municipal codes, laws and regulations for thermal insulation and vapor retarders.
3. The contractor must maintain a copy of Safety Data Sheets (SDS), technical data sheet, and jobsite conditions log on file and at the job site at all times and make available upon request to the Customer, Project Inspector, Program Implementer, or NYSERDA.
4. Prior to initiating the project, the contractor must provide customers with access to accurate information regarding spray foam installation, including SDS, information on requirements to vacate premises, odors related to the work.
5. The contractor must list the names and makes of the specific products used on invoices to the customer contract or invoice and all invoices to NYSERDA programs.
6. Saving estimates must be based on the rated R-value for the specific product used.
7. The rigs used to process high pressure foam systems must be self-powered. Using power from the client property by opening a client electrical panel and inserting a circuit breaker or connecting wires to an existing circuit breaker is strictly prohibited.
8. The jobsite conditions log must contain the following:
    a. Contractor name and contact information
    b. Names of crew members on site
    c. Material manufacturer name and contact information
    d. Specific product name and manufacturer lot number
    e. Processing equipment type, pump size, gun type, tip size

f. Quantity of materials used measured in strokes or pounds
g. The following data must be collected at the start of foam ops, any time a drum is changed out, and at the completion of foam ops:
    - Ambient temperature, RH, Dew Point
    - Surface Temperature, % Moisture
    - Acceptable ranges for these measurements as per the product installed
    - Measured ventilation rate in confined spaces where applicable

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B.3 Health and Safety Requirements

1. Contractors must ensure that occupants and staff are informed of, and follow, manufacturer's requirements, regarding: who may be present during spraying; how far away occupants and pets must be kept during work; and when occupants and pets can re-enter premises.
2. Contractors must ensure that staff on-site during spraying are provided with and use proper equipment such as goggles, respirators, clothes and gloves, as required by manufacturer.
3. Temporary space heating required during foaming operations must be provided by vented or non-open flame sources. Smoking must be prohibited.
4. During foaming operations, two air changes per hour of ventilation must be maintained for installation personnel, and the installer must otherwise ensure an acceptable level of indoor air quality as per OSHA standards.

○*OPTIONAL BEST PRACTICE*○ It is recommended that all staff involved in application obtain training from the suppliers of SPF to help ensure installation quality and use of all equipment as well as safe handling, use, and disposal of all chemicals used in the process. The Spray Polyurethane Foam Alliance (SPFA) offers additional training and accreditation for SPF applications. The American Chemistry Council website www.spraypolyurethanefoam.org offers two certifications, one for Low Pressure Polyurethane Foam Systems, and another for High Pressure Polyurethane Foam Systems. These courses may be used for BPI CEU credits.

B.4 Materials

B.4.1 Protection of Materials

1. Contractors must follow manufacturer's guides regarding transportation and storage of materials.
2. Insulation materials must be protected from physical damage and from becoming wet, soiled, or covered with ice or snow between phases of the work or after the completed

installation. Materials must not be exposed to sunlight, except to the extent necessary for period of installation and concealment.

3. Insulation materials must be protected against ignition at all times.
4. Materials must be protected from freezing or extreme heat. Chemical components must be maintained at a minimum of 60 degrees while stored on site.

B.4.2 Specifications

1. Polyurethane foam product to be a two-component mix for producing high quality rigid insulation.
2. All products must be labeled with Model Building Code approvals and ICC ESR, UL, or FM listings where required.
3. Surface-burning characteristics: Maximum flame-spread and smoke developed indices of 25 and smoke <450, respectively, when tested in accordance with ASTM E-84 or UL 723.
4. ASTM C-518 Aged R Value, meet or exceed as follows:
   - Low Pressure Closed Cell SPF: R-5 per inch of thickness
   - High Pressure Closed Cell SPF: R-6 per inch of thickness
   - High Pressure Open Cell SPF: R-3.5 per inch of thickness

5. ASTM 1622 Core Density within the range of:
   ii. Closed Cell SPF: 1.7 to 2.2 pounds per cubic foot
   iii. Open Cell SPF: 0.5 to 0.7 pounds per cubic foot

6. ASTM D6226 Closed-cell content: 90 percent minimum.

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B.5 Fire Protection

1. In situations where the foam insulation is installed in a space that is difficult to access, is segregated from other interstitial or occupied space by a prescriptive thermal barrier, and has no floor in it, but where there may exist an HVAC device, wiring, piping, or ductwork, it is a “space accessible only to service mechanical devices”. Foamed plastic in interior applications in these spaces must be protected by an approved IGNITION barrier, as follows:

   a. Prescriptive ignition barriers including, but are not limited to, the following:
      - 1 ½ -inch-thick (38 mm) mineral fiber insulation;
      - ¼ -inch-thick (6.4 mm) wood structural panels
      - 3/8-inch (9.5 mm) particleboard;

- ¼ -inch (6.4 mm) hardboard;
- 3/8-inch (9.5 mm) gypsum board
- Corrosion-resistant steel having a base metal thickness of 0.016 inch (0.406 mm).

b. Other materials that can stop ignition as well as or better than the prescriptive materials listed above and tested in accordance with International Code Council Evaluation Services Acceptance Criteria 377 Appendix X (ICC-ES AC 377 Appendix X). In cases where ICC-ES AC 377 Appendix X is used, proper ICC ESR documentation is required.

2. A thermal barrier is not required for the installation of foam on a sill plate/rim joist area, provided that the maximum thickness of the foam is 3 ¼ inches.
3. In all other cases, including all areas that could be used for storage, foam must be covered by a THERMAL Barrier, as follows:
    - ½ inch thick Sheetrock.
    - Other materials that will delay the surface of foam from experiencing surface temperature increase equal to or more than 250°F in 15 minutes AND are proven to remain in place under fire conditions. The alternate products must have ICC ES reports proving that they are acceptable alternate thermal barriers for the specific foam product installed.

B.6 Preparation

1. Prior to beginning work, the contractor must examine all substrates and conditions for compliance with installation requirements to determine if conditions affecting performance of insulation are satisfactory. Examine all substrates for soundness, such as tightness of connections, crumbling or looseness of surface, level tolerance of surface, and other conditions which would affect the installation. Joints in insulation, sheathing, and other substrate components must be solidly supported and fastened.
2. The contractor must clear all cracks, spaces, voids, cavities, and openings to be sealed of debris, moisture, ice, and materials prior to the commencement of foaming operations. Clean substrates of substances harmful to insulations, including moisture, dirt, or un-bonded coatings that will affect the insulation or prevent an airtight seal. Remove projections which might puncture vapor retarders.
3. To prevent foam leakage, all joints must be sealed and openings in the sheathing closed off in the areas to be sprayed.
4. Wiring, conduit, boxes, etc. must be braced or fastened securely so that expansion of foam sealant must not cause wiring to "float." Wiring must be located within the wall/ceiling cavity to be foamed so as to prevent damage to wiring during the trimming and/or planing of the foam. Ensure that all electrical connections are made in a box, and that all boxes

have covers securely screwed shut. Non-metallic electrical wiring in the areas to be sprayed must be Type NMB or NMC-B.

5. Areas, belongings and gas and water pipes to be protected must be masked from over-spray. ○*OPTIONAL BEST PRACTICE*○ Wrap copper water lines in pipe insulation before spraying around them because hot water makes the pipes move. When they move undesirable sounds may occur if foam is applied directly to them.
6. The contractor must not proceed with installation until unsatisfactory conditions have been corrected in a manner acceptable to the customer, the installer and the Program Implementer.

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B.7 Installation

1. The component ratio must be maintained and the components of the polyurethane chemicals mixed in accordance with the manufacturer's product specifications and processing instructions in order to achieve the desired density and physical properties. Product should be test-sprayed off target and must be periodically checked to be sure it is on ratio, has correct “froth” state, and has proper density.
2. The component temperatures must be maintained in accordance with the manufacturer's product specifications and processing instructions to achieve the desired mix, density, and physical properties. For example, 2-part foam in canisters typically must be at or above 70° F for 24 hours before and throughout use of the product.
3. Continuity of the air/vapor barrier created by the spray-applied polyurethane foam insulation system must be maintained at all intersections of the building assemblies (floor to foundations, walls to floors, walls to roofs, etc.), across expansion and control joints, and around elements penetrating through the building envelope (doors, windows, louvers, vents, etc.) by sealing as per Program air sealing and insulation installation requirements.
4. Insulation must be applied onto the substrate to a minimum or average cured depth/thickness in consecutive passes of no more than the maximum lift thickness recommended by the manufacturer. Thickness specifications must be at invoiced levels. Areas determined to be less than this tolerance must be re-coated to the minimum and areas greater than this tolerance, if extending beyond the framing that will be enclosed, must be trimmed to the maximum specified thickness.
5. The ambient and substrate temperatures at the time of application must be at or above the minimum required by the manufacturer before and during the foam installation. The manufacturer’s minimum cure temperature must be maintained for the required period after the foam has been installed. For example, foam from 2-part foam canisters must typically be applied to surfaces at or above 50° F. No foam may be applied if the surface temperature at the time of application is within 5 degrees of dew point.

6. In colder climates (IECC zones 5&6) the SPF used must be installed at a thickness of at least Class II vapor retarder or have at least Class II vapor retarder coating or covering in direct contact with the inside surface of the SPF.
7. Foam must be trimmed flush with the inside surfaces. Foam must be removed from finished surfaces such as window glass, casings, and gypsum board.
8. The contractor must ensure that any access panels or openings required for maintenance remain accessible.

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APPENDIX C: Health and Safety: Additional Worker Considerations When Working in Attics

Extreme Heat

During hot sunny periods the temperature in the attic can climb to 120 degrees, and as high as 150+ degrees. During these periods care must be taken to ensure worker health. During off times workers must be sure to drink plenty of fluids and be assessed for signs of heat related illnesses. ○*OPTIONAL BEST PRACTICE*○ Limit worker limit in the attic to 15 minutes on and 15 minutes off.

Inadequate Light

Adequate lighting must be provided and care must be taken to avoid potential dangerous situations.

Hazardous Materials

Asbestos, molds, and animal feces are all possible materials found in an attic.

Electric Shock Hazard

Exposed wires, uncovered boxes, perspiration caused by extreme heat and exertion can combine to create a dangerous situation.

Falling Hazard

1. Attic level changes or loose debris can result in falling in the attic. Care must be taken when moving about the attic.
2. The contractor must ensure that workers are provided with adequate fall protection for open-joist attic work.

Confined Spaces

Some attics may have low head room or severely limited access. The contractor must follow OSHA safety regulations when attic spaces qualify as confined spaces.