Workforce Guidelines for Home Energy Upgrades
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Introduction

On October 19, 2009, Vice President Biden unveiled the Recovery Through Retrofit report that builds on the foundation laid in the 2009 Recovery Act to expand clean energy job opportunities and boost homeowner energy savings by making residential buildings more energy efficient. The report identified the lack of a skilled workforce as one of three key barriers to scaling up the residential energy efficiency retrofit market. To address this barrier, the report recommended establishing a uniform suite of voluntary national standards, or “guidelines,” for worker training and certification.

The Recovery Through Retrofit Workforce Working Group, which includes the U.S. Department of Energy (DOE), the U.S. Department of Labor, the U.S. Environmental Protection Agency (EPA), the U.S. Department of Education, the U.S. Small Business Administration, and the U.S. Department of Health and Human Services, then detailed the four interrelated components of the Workforce Guidelines for Home Energy Upgrades: Job Task Analyses; Essential Knowledge, Skills, and Abilities; Standard Work Specifications; and a Technical Standards Reference Guide.

The Workforce Guidelines for Home Energy Upgrades also has its origins in the Weatherization Assistance Program Training and Technical Assistance (WAP T&TA) Plan. The T&TA Plan seeks to ensure that Recovery Act investments help lay a permanent foundation for a stronger Weatherization Assistance Program. This foundation will support enduring employment opportunities for weatherization workers hired to support the Recovery Act ramp-up, workers who are currently underemployed or dislocated and seeking new prospects, and workers who have relevant skills and are looking for an entry point into this exciting and rapidly expanding industry. To support these objectives, the WAP T&TA Plan calls for a voluntary national framework for worker certification and training program accreditation, a framework contingent on the development of Workforce Guidelines for Home Energy Upgrades that is recognized by both the national Weatherization Network and broader home energy efficiency retrofit industry.

The DOE National Renewable Energy Laboratory (NREL) led the development of the Workforce Guidelines for Home Energy Upgrades in a process that involved a historic collaboration between Weatherization Assistance Program technicians and trainers, home performance contractors, building scientists, organized labor, healthy homes professionals and other technical experts in the building trades and throughout the retrofit industry. The guidelines build upon the considerable but incomplete body of material already in circulation, and the cumulative knowledge gathered throughout the nation’s 30-year history of the performing energy efficiency retrofits of residential homes.

In addition to the involvement of energy efficiency retrofit professionals, the guidelines underwent a thorough review by healthy homes and worker safety experts. Staffs from the EPA, the Occupational Safety and Health Administration (OSHA), and the National Institute for Occupational Safety and Health participated in writing and reviewing the guidelines to include worker and homeowner safety.

This document includes the following components for the four most common weatherization and energy efficiency retrofit job classifications: Energy Auditor, Retrofit Installer/Technician, Crew Leader, and Inspector/Quality Assurance Professional.

- **Standard Work Specifications** define the performance requirements for high quality energy efficiency retrofit work and the minimum conditions necessary to achieve the desired outcomes of a given retrofit measure.
• **Technical standards** encompass standards, regulations and codes developed by government, industry or third-party standards development organizations—such as OSHA, the EPA, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), ASTM International, and the Building Performance Institute—and define the safety, materials, installation, and application standards relevant to residential building energy efficiency retrofits.

• **Job Task Analyses** identify and catalog all of the tasks a given worker typically performs when completing a suite of energy efficiency improvements in a home.

• **Essential KSAs** identify the minimum knowledge, skills, and abilities that a skilled worker should possess to perform high quality energy efficiency retrofit work.

Once finalized, the *Workforce Guidelines for Home Energy Upgrades* will:

1. Enable the Weatherization Assistance Program and residential retrofit program administrators nationwide to strengthen their field guides and other work manuals by incorporating the high quality Standard Work Specifications contained in the guidelines.

2. Assist training providers in developing academic and job training course content and curricula consistent with an industry recognized suite of Job Task Analyses and Knowledge, Skills, and Abilities.

3. Build confidence amongst consumers and the energy efficiency finance community that retrofit work will be completed in a quality manner and produce the expected energy savings and health benefits.

4. Facilitate additional technical standards development by the appropriate industry group or third-party standards development organization.

5. Increase workforce mobility up career ladders and across career lattices by establishing a clear set of essential Knowledge, Skills and Abilities upon which worker credentials should be based.

6. Lay the foundation for a more robust worker certification and training program accreditation architecture.

The Standard Work Specifications for Energy Efficiency Residential Retrofits section is organized by sections corresponding to the different systems found in residential buildings. Within each section are subtopics and details. The details contain the critical specification that must be achieved to ensure quality work. Throughout the standard work specifications are footnotes referring to the relevant technical standards, which are then summarized in Appendix D.

The Job Task Analysis and Essential Knowledge Skills and Abilities section is made up of content outlines for the four common energy efficiency retrofit job classifications. They were developed by professional psychometricians working with experienced technicians from the Weatherization Assistance Program, the residential energy efficiency retrofit contractor community, and organized labor. The content outlines were generated through a Develop-A-Curriculum (DACUM) process and provide a detailed inventory of the minimum knowledge, skills and abilities—both cognitive and psychomotor—that a worker should possess to perform high quality energy efficiency retrofit work. Part two of this effort (spring of 2011) will introduce DACUM charts for all four job descriptions, which will support curriculum development in training programs nationwide.
Acknowledgements

The Workforce Guidelines for Home Energy Upgrades was developed by the NREL with the participation of a broad cross section of industry representatives, including technicians from the Weatherization Assistance Program, residential energy efficiency retrofit professionals, healthy homes and worker safety experts, NREL residential building scientists, and psychometricians.

Over 156 industry representatives collaborated in the development of the Workforce Guidelines for Home Energy Upgrades. NREL acknowledges and appreciates the efforts of these individuals who traveled throughout the summer to attend numerous work sessions at NREL in Golden, Colorado, and who gave their time, expertise, and experience in generous proportions. Many rescheduled vacations and rearranged other work commitments to meet the ambitious goal of providing DOE with draft standards for federal agency review by August 2010.

NREL also acknowledges the work performed by its subcontractors in helping to meet the accelerated deadlines of this project. Their expert facilitation process and extensive knowledge of the residential energy efficiency retrofit industry was critical in enlisting the help of so many accomplished key experts.

Specifically, NREL would like to thank the 33 professionals who put together the original draft of the Standard Work Specifications which are built on the considerable material already in circulation nationwide and the wealth of knowledge learned through 30 years of performing energy efficiency retrofits in homes. NREL also convened 43 retrofit professionals and Weatherization Assistance Program technical experts to review and edit the Standard Work Specifications for Energy Efficiency Residential Retrofits section for climate specific variations, technical accuracy and health and worker safety perspectives.

NREL also wishes to thank the 50 participants in the Job Task Analyses and Essential Knowledge, Skills, and Abilities work session. These individuals, with the guidance of three skilled psychometricians, identified and cataloged all of the steps a given worker typically performs when completing a suite of energy efficiency improvements in a home, and the minimum knowledge, skills, and abilities that a skilled worker should possess to perform high quality energy efficiency retrofit work.

Finally, NREL offers special thanks to DOE program leadership for guidance and to the White House Council on Environmental Quality and the Vice President’s Office for vision and leadership to initiate the project.
The Relationship Between the U.S. Department of Energy’s Workforce Guidelines for Home Energy Upgrades and the Environmental Protection Agency’s Healthy Indoor Environment Protocols for Home Energy Retrofits

The U.S. Department of Energy (DOE) Weatherization Assistance Program and the broader residential energy efficiency retrofit industry are experiencing significant growth as a result of investments made through the American Recovery and Reinvestment Act and increased societal awareness of the economic, employment, and health benefits of reducing home energy consumption.

In support of this expansion, DOE and the U.S. Environmental Protection Agency (EPA) are developing two keystone documents pertaining to quality and health considerations in residential energy efficiency retrofits. These documents are being developed in conjunction with one another and are complementary and mutually supportive. Both are intended to provide a set of voluntary measures that the Weatherization Assistance Program and other energy efficiency retrofit efforts can adopt to increase the quality of the retrofit work performed while maintaining or improving the health and safety of the occupant.

Together, the two documents will:

- Provide a robust and practical set of resources for retrofit contractors, trainers, and program administrators
- Help improve the quality of the work performed in this expanding industry
- Promote occupant health and safety
- Drive consumer demand for energy efficiency retrofit services.

DOE and the EPA have collaborated closely throughout the production of these two documents. In particular, the two agencies have strived to make certain that the EPA minimum actions are fundamentally integrated appropriately into the DOE Standard Work Specifications for Energy Efficiency Retrofits, which form the bulk of the guidelines, so that retrofit workers following the DOE document will inherently achieve the EPA minimum recommendations. Any inconsistencies will be reconciled during the forthcoming public comment periods for both of these documents. Additionally, both DOE and the EPA fully support the retrofit industry going above and beyond the minimum actions by adopting the EPA-recommended expanded actions, but both agencies also understand that financial or programmatic constrains may impede this in certain cases.

About the DOE Workforce Guidelines for Home Energy Upgrades Document

The DOE Workforce Guidelines for Home Energy Upgrades contains a comprehensive set of standard work specifications for a wide range of energy efficiency retrofit measures. These standard work specifications define the minimum requirements for high quality energy
efficiency retrofit work and the proper conditions necessary to achieve the desired outcomes of a given retrofit measure.

Once finalized, the DOE standard work specifications will enable the Weatherization Assistance Program and other residential retrofit program administrators nationwide to strengthen their field guides, work manuals, and other programmatic requirements for workers and contractors. The standard work specifications should be followed by all retrofit programs aiming to build confidence amongst consumers, program officials, the energy efficiency finance community, and the general public that retrofit work will be of high quality and produce the expected energy savings and health protections for the occupants.

About the EPA Healthy Indoor Environment Protocols for Home Energy Retrofits Document

The EPA Healthy Indoor Environment Protocols for Home Energy Retrofits focuses primarily on the health and safety of the building occupants. The EPA document includes recommended assessment protocols to identify indoor environmental quality issues, recommended minimum actions, and opportunities for expanded actions to promote improved occupant health through home energy retrofits. Each of these is described below.

- **Assessment protocols** provide EPA-recommendations for evaluating both existing conditions of concern and the potential for additional health concerns that may arise as a result of retrofit activities.

- **Minimum actions** include actions that weatherization and home energy retrofit contractors should take to ensure that the work they perform in a home does not introduce new health concerns or make existing conditions worse. These actions often reference existing technical and safety standards.

- **Expanded actions** include recommended indoor environment improvements that can be made during many home energy retrofit projects. These actions are usually low-cost, simple improvements that can be performed by home energy retrofit workers with proper training and sufficient resources.
Disclaimer Regarding the Use of the Workforce Guidelines for Home Energy Upgrades as Tools for Employment Selection

If the Workforce Guidelines for Home Energy Upgrades are used with respect to actual employment decisions, they must be used in compliance with the federal equal employment opportunity laws, enforced by the U.S. Equal Employment Opportunity Commission (EEOC).

If the National Guidelines are used as tools for employment selection, their use would violate the federal anti-discrimination laws if an employer intentionally uses them to discriminate based on race, color, sex, national origin, religion, disability, or age. (See http://www.eeoc.gov/policy/docs/factemployment_procedures.html)

Moreover, neutral use of employment selection procedures can violate the federal anti-discrimination laws if they have the effect of disproportionately excluding people in a particular group by race, sex, or another covered basis, unless the employer can show that the selection procedure is job related and consistent with business necessity. An employer can meet this standard by showing that the selection procedure is necessary to the safe and efficient performance of the job, in other words, associated with the particular knowledge, skills, and abilities needed to perform the job successfully, as opposed to simply a general measurement of skills.

Under Title I of the Americans with Disabilities Act (ADA), it is unlawful to fail to make reasonable accommodations to the known physical or mental limitations of an applicant or employee who is an individual with a disability who is qualified for the position, unless such accommodation would impose an undue hardship. See 42 U.S.C. § 12112(b)(5).

For more information on prohibited employment practices and policies, please visit http://www.eeoc.gov/laws/practices/index.cfm

For more information on the U.S. Equal Employment Opportunity Commission, please visit their homepage at: http://www.eeoc.gov/
CONTENTS AT A GLANCE

PART I: 1 - 564
STANDARD WORK SPECIFICATIONS FOR ENERGY EFFICIENCY RESIDENTIAL RETROFITS

PART II: 565 - 620
JOB TASK ANALYSIS OUTLINES
# CONTENTS AT A GLANCE

## PART I:

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERALL TABLE OF CONTENTS</td>
<td>2</td>
</tr>
<tr>
<td>SECTION 1: HOME PERFORMANCE ASSESSMENT</td>
<td>13</td>
</tr>
<tr>
<td>SECTION 2: COMBUSTION APPLIANCES</td>
<td>32</td>
</tr>
<tr>
<td>SECTION 3: VENTILATION</td>
<td>53</td>
</tr>
<tr>
<td>SECTION 4: AIR SEALING</td>
<td>114</td>
</tr>
<tr>
<td>SECTION 5: HEATING AND COOLING</td>
<td>172</td>
</tr>
<tr>
<td>SECTION 6: INSULATION</td>
<td>256</td>
</tr>
<tr>
<td>SECTION 7: CRAWL SPACES AND BASEMENTS</td>
<td>320</td>
</tr>
<tr>
<td>SECTION 8: BASELOAD</td>
<td>371</td>
</tr>
<tr>
<td>GLOSSARY</td>
<td>430</td>
</tr>
<tr>
<td>APPENDIX D</td>
<td>435</td>
</tr>
</tbody>
</table>

## PART II:

<table>
<thead>
<tr>
<th>Role</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY AUDITOR</td>
<td>566</td>
</tr>
<tr>
<td>CREW LEADER</td>
<td>587</td>
</tr>
<tr>
<td>RETROFIT INSTALLER / TECHNICIAN</td>
<td>592</td>
</tr>
<tr>
<td>QUALITY CONTROL INSPECTOR</td>
<td>610</td>
</tr>
</tbody>
</table>
PART I: 1 - 56
STANDARD WORK SPECIFICATIONS FOR ENERGY EFFICIENCY RESIDENTIAL RETROFaTS
Overall Table of Contents:

SECTION 1: HOME PERFORMANCE ASSESSMENT

Assessment
   1) Essential Home Assessment Components

Appendix A

Home Assessment Guidelines
Industry Home Assessment Standards
Industry Home Assessment Comparison Table

SECTION 2: COMBUSTION APPLIANCES

Health and Safety

Safe Work Practices:
   1) Combustion Worker Safety

Combustion Appliance Zone (CAZ) Testing:
   2) Depressurization Test
   3) Spillage Test
   4) Draft Test
   5) Carbon Monoxide Test
   6) Gas Leak Detection

Combustion Appliances

Unvented Space Heaters:
   7) Propane, Natural Gas and Kerosene Heaters

Vented Gas Appliances:
   8) Combustion Air for Atmospherically Vented Appliances
   9) Combustion Flue Gas – Orphaned Water Heater
   10) Draft Regulation – Category I Appliance
Safety Devices:
   11) Smoke Detector
   12) Carbon Monoxide Detector or Monitor

Appendix B

Combustion Appliance Zone (CAZ) Depressurization Limits Table

SECTION 3: VENTILATION

Health and Safety

Safe Work Practices:
   1) Ventilation Worker Safety

Exhaust

Components:
   2) Ducts
   3) Terminations
   4) Exhaust Grille Location

Fans:
   5) Surface Mounted Ducted
   6) Inline
   7) Direct Vent
   8) Multi-Port System
   9) Garage Exhaust Fan

Appliance Exhaust Vents:
   10) Clothes Dryer
   11) Kitchen Range

Special Considerations:
   12) Regional Considerations
Supply

Components:
13) Supply Register Location
14) Intakes
15) Ducts for Supply
16) Intake to Forced Air System

Fans:
17) Inline or Multi-Port

Special Considerations:
18) Regional Considerations

Whole House Ventilation:

Air Flow Requirements:
19) Installed System Air Flow
20) Primary Ventilation Air Flow Between Rooms

Other Components:
21) Controls
22) Heat Recovery Ventilation (HRV) and Energy Recovery Ventilator (ERV) Installation

Dehumidifiers:
23) Stand Alone
24) Ventilator

Special Considerations:
25) Regional Considerations
26) Hot and Humid Climate Impact
27) Sound Rating Limits

Appendix C:
Supplemental Ventilation Information
SECTION 4: AIR SEALING

Safe Work Practices:
1) Air Sealing Worker Safety
2) Air Sealing Moisture Precautions
3) Radon

Attic Sealing

Penetrations and Chases:
4) Penetrations
5) Chase Sealing
6) Chase Capping
7) Pocket Door

Open Stairwells:
8) Interior with Sloped Ceiling
9) Stairwell to Attic - Door at Bottom with No Ceiling Above
10) Stairwell to Attic - Door at Top with Finished Ceiling Above

Dropped Ceilings and Soffits:
11) Raised Top-Plate with Walls Open to Attic
12) New Ceiling Below Original - Old Ceiling Intact or Repairable
13) Above Closets and Tubs
14) Ceiling Leaks Not Repairable – No Air Barrier Above
15) 3-D Walls
16) Dropped Ceiling with Light Boxes and Fixtures
17) Dropped Soffits

Other Ceiling Types:
18) Tongue and Groove Ceilings
19) Cathedralized Attic Ceilings

Considerations:
20) Regional Considerations

Garage Sealing

Garage Openings:
21) Penetrations, Cracks and Doors between Garage and House
Window and Door Sealing

Maintenance and Repair:
22) Double-Hung Wood Windows
23) Single-Unit Window and Fixed Frame with Wood Sash
24) Exterior Doors

Cracked and Broken Glass:
25) Fixed Frame with Wood Sash — Older House
26) Single-Unit Window, Mounted on Rough Opening — Newer House

Replacement:
27) Fixed Frame with Wood Sash — Older House
28) Single-Unit Window, Mounted on Rough Opening — Newer House

SECTION 5: HEATING AND COOLING

Health and Safety

Safe Work Practices:
1) Heating and Cooling Worker Safety

Forced Air

Design:
2) Load Calculation and Equipment Selection
3) Ductwork and Termination Design

Equipment Installation:
4) Preparation for New Equipment
5) Fuel Delivery System for Fuel Oil
6) Fuel Delivery System for Natural Gas and Propane
7) Setting of Air Handler
8) Duct System
9) Heating and Cooling Controls
10) Venting System
11) Condensate Drainage of Heating and Air Conditioning Equipment
12) Regional Considerations
Commissioning of Equipment:
13) Leak Detection
14) Data Plate Verification
15) Venting System
16) Combustion Analysis
17) Air Flow
18) Electrical Service
19) Refrigerant Line Inspection
20) Sequence of Operation
21) Occupant Education
22) Evaporative Cooler Maintenance and Repairs
23) Regional Considerations

Ducts

Duct Sealing:
24) Preparation and Mechanical Fastening
25) Support
26) Sealing System
27) Proprietary Spray Application
28) Sealing System Components
29) Return – Framed Platform
30) Dual Cooling Up Ducts
31) Removing Supply Vents From Garages

Duct Insulation:
32) Insulating Flex Ducts
33) Insulating Metal Ducts

Hydronic Heating

Design:
34) Heat Load Calculation – Whole House
35) Space Load Calculation – Heat Emitter Sizing

Equipment:
36) Boiler – Pressure Relief Safety Valve
37) Boiler Replacement – Gas and Oil
38) Controls – Thermostat Replacement
Maintenance:
   39) Gas Boiler – Annual Service
   40) Checklist

SECTION 6: INSULATION

Health and Safety

Safe Work Practices:
   1) Insulation Worker Safety

Attic

Preparation:
   2) Non-Insulation Contact (IC) Recessed Light
   3) Knob and Tube Wiring
   4) Fireplace Chimney and Combustion Flue Vents
   5) Vented Eave or Soffit Baffles
   6) Dense Pack Preparation

Attic Ceilings:
   7) Loose Fill Over Pitched Ceilings
   8) Dense Pack Over Pitched Ceilings
   9) Unvented Flat Roof with Existing Insulation
  10) Dense Pack Cape Cod Side Attic Roof

Knee Walls:
   11) Preparation for Dense Packing
   12) Preparation for Batt Insulation
   13) Strapping for Existing Insulation
   14) Knee Wall without Framing

Accessible Attic Floors:
   15) Batt Installation
   16) Loose Fill Installation
   17) Loose Fill Over Existing Insulation
   18) Batt Insulation Over Existing Insulation

Enclosed Attic Floors:
19) Dense Pack Installation – Bonus Room Floor
20) Dense Pack Installation – Attic Storage Platform

Attic Openings:
21) Pull Down Stairs
22) Access Doors and Hatches
23) Whole-House Fan

Attics General:
24) Ventilation
25) Radiant Barrier
26) Skylights
27) Parapet Walls

**Exterior Walls**

Preparation:
28) Exterior Dense Pack

Accessible Exterior Walls:
29) Open Wall Insulation

Enclosed Exterior Walls:
30) Dense Pack Exterior Walls
31) Additional Exterior Wall Cavities

**Floors**

Accessible Floors:
32) Batt Installation Floor System
33) Loose Fill Floor System with Netting
34) Loose Fill Floor System with Rigid Barrier
35) Batt Installation Cantilevered Floor
36) Pier house subfloor insulation – Batt installation with rigid barrier
37) Pier house subfloor insulation – loose fill with rigid barrier
SECTION 7: CRAWL SPACES AND BASEMENTS

Health and Safety

Safe Work Practices:
1) Crawl Space and Basement Worker Safety
2) Combustion Safety
3) Material Selection, Labeling and Material Safety Data Sheets (MSDS)

Separation of Basements and Crawl Spaces:
4) Basements Connected to Crawl Spaces

Crawl Space Health and Safety:
5) Radon
6) Access
7) Crawl Space Information Sign
8) Occupant Education
9) Return and Supply Plenums
10) Warranty and Service Agreement

Basement Health and Safety:
11) Knob and Tube Wiring

Crawl Spaces

Site Preparation:
12) Pre-Work Qualifications
13) Debris Removal
14) Drainage
15) Preliminary Dehumidification
16) Negative Pressure Contamination Control
17) Sealing Floor Penetrations
18) Regional Considerations

Vented Crawl Spaces:
19) Ground Moisture Barrier
20) Venting

Closed Crawl Spaces:
21) Skirting on Post and Pier Foundations
22) Air Sealing the Foundation Vents
23) Air Sealing the Exterior Wall
24) Air Sealing Brick Curtain Wall with Piers  
25) Vapor Retarders on Walls  
26) Attached Crawl Spaces Under Unconditioned Spaces  
27) Wall Insulation  
28) Ground Moisture Barrier  
29) Crawl Space Conditioning  
30) Regional Considerations  

Basements

Insulation and Conditioning:
   31) Basement Wall Insulation –No Ground Water Leakage  
   32) Basement Wall Insulation –Ground Water Leakage  
   33) Dehumidification

SECTION 8: BASELOAD

Health and Safety

Safe Work Practices:
   1) Baseload Worker Safety

Baseload

Plug Load:
   2) Refrigerator and Freezer Replacement  
   3) Cleaning and Tuning Existing Refrigerators and Freezers  
   4) Entertainment and Computer Systems and Components Replacement  
   5) Lighting  
   6) Washing Machine  
   7) Clothes Dryer Replacement  
   8) Dehumidifiers  
   9) Removal of Electrically Heated Waterbed Mattress  
  10) Regional Considerations
**Water Heating**

**Energy Use:**
11) Water Heater Selection  
12) Shower Head and Faucet Aerator

**Installation and Replacement:**
13) Storage Type Appliance  
14) On Demand Appliance  
15) Regional Considerations

**Routine Maintenance:**
16) Storage Type Appliance  
17) On Demand Appliance

**Shading:**

**Landscaping:**
18) Indigenous Shading

**GLOSSARY**

**APPENDIX D**
Referenced Standards
SECTION 1: HOME PERFORMANCE ASSESSMENT

Table of Contents

Comprehensive Assessment:

Assessment
  1) Essential Home Assessment Components

Appendix A

Home Assessment Guidelines
Industry Home Assessment Standards
Industry Home Assessment Comparison Table
**Topic: Comprehensive Assessment**  
**Subtopic:** Assessment

1) **Detail Name:** Essential Home Assessment Components*

**Desired Outcome:**
- Every home assessed for improvement opportunities in required areas (health, safety, durability, environmental impact) and in requested areas (comfort, energy cost payback analysis) will offer the primary occupant clear instruction on suggested improvements

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<thead>
<tr>
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<td>1</td>
<td>Health</td>
<td>All homes will be assessed for health hazards, including all areas identified in the Home Performance Assessment Input Table*&lt;br&gt;Combustion testing will be conducted in accordance with the Building Performance Institute (BPI) protocol or other equivalent protocol</td>
<td>Discover home related issues that could pose health hazards&lt;br&gt;Identify opportunities for improvement</td>
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<td>Safety</td>
<td>All homes will be assessed for safety hazards, including all areas identified in the Home Performance Assessment Input Table (e.g., electrical, structural, confined spaces)</td>
<td>Discover home related issues that could pose a safety hazard&lt;br&gt;Identify opportunities for improvement</td>
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<td>Durability</td>
<td>All homes will be assessed for condition issues, including all areas identified in the Home Performance Input Table (e.g., corrosion, decay, UV, wood rot)</td>
<td>Discover home conditions that could pose a risk to durability&lt;br&gt;Identify opportunities for improvement</td>
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<td>Comfort</td>
<td>Occupants will be given the opportunity to identify whether improved comfort is a goal for the assessment&lt;br&gt;Upon occupant request, the home will be assessed for comfort improvement</td>
<td>Discover home conditions that could interfere with comfort&lt;br&gt;Identify opportunities for improvement</td>
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<tr>
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| 5 | Energy | **Funders or occupants will be given the opportunity to identify whether energy reduction is a goal for the assessment**
Upon occupant or funder request, the home will be assessed for energy reduction opportunities, including all areas identified in the Home Performance Input Table
A full energy reduction assessment using a Department of Energy (DOE) approved method or software will be conducted
Discover energy reduction opportunities (whenever a return on investment evaluation is a desired outcome of the occupants or funders) |
| 6 | Occupant education | Occupants will be educated on operating and managing their home after improvements
Provide occupant education on all areas of assessment
Increase occupant involvement in household operation and energy management that enhances effectiveness of improvements |
| 7 | Environmental improvements | All homes will be assessed for environmental improvement opportunities, including all areas identified in the Home Performance Input Table (e.g., water use, carbon reduction, recycling)*
Discover opportunities to reduce environmental impact |

*For more information see Appendix A
APPENDIX A:

Home Assessment Guidelines

Occupant Interview
- Review energy bills (if available)
- Discover significant heating and cooling concerns
- Identify occupant living habits and needs

Combustion Appliance Safety
- Visually inspect units for damage or maintenance
- Inspect for fuel leaks using approved methods
- Inspect for clearance to combustibles
- Test ambient carbon monoxide (CO)
- Test for CO in undiluted flue gases
- Test for CO on gas cook stoves
- Conduct worst-case Combustion Appliance Zone (CAZ) testing
- Identify combustion air source according to ASHRAE 62.2-2010
- Inspect safety shut offs
- Inspect heat exchanger condition, maintenance and efficiency
- Remove or vent unvented space heaters

Heating, Cooling and Hot Water Systems
- Evaluate furnace performance and efficiency
- Evaluate cooling maintenance, installation, performance and efficiency
- Determine dominant duct leakage
- Conduct pressure pan, duct blaster or Delta Q tests as necessary
- Measure room pressure imbalances in houses with forced-air systems
- Resolve room pressure imbalances
- Evaluate duct performance, including filter effectiveness and duct sizing
- Evaluate R-value of duct insulation
- Evaluate water heater condition, performance and efficiency
- Evaluate R-value of pipe insulation

Indoor Air Quality and Ventilation
- Test minimum ventilation rates and building tightness limits based on ASHRAE 62.2-2010
- Test spot ventilation to ASHRAE 62.2-2010

Building Envelope: Air Sealing and Insulation Levels
• Determine square footage and approximate age of house
• Determine R-values of wall, ceiling and floor insulation
• Determine type and condition of doors
• Determine type of windows: glazing type(s) and frame material(s)
• Identify thermal bypasses and thermal bridges
• Determine type, model number and location of heating and cooling system(s)
• Determine type of ductwork, location and R-value of duct insulation and any indications of previous duct sealing
• Determine type of foundation (e.g., crawl space, basement, slab) and any insulation
• Conduct blower door test to determine air-leakage rate of the building enclosure
• Conduct visual inspection to identify paths of air leakage
• Conduct zone pressure diagnostics and interpret results
• Determine the location and effectiveness of the air barrier

**Moisture Control**
• Identify exterior water intrusion
• Indentify interior moisture sources
• Indentify effects of water damage (e.g., mold, mildew, insect damage)
• Evaluate condition of downspouts and flashing
• Verify presence of properly applied vapor retarders

**Baseload**
• Inspect domestic hot water tank temperature and insulation
• Evaluate major appliance performance and efficiency (especially refrigerators)
• Evaluate lighting performance and efficiency

**Computer Simulation**
• Input accurate house data and determine appropriate, cost-effective retrofit measures

**Health and Safety Issues**
• Identify electrical hazards and notify occupant
• Identify fire or structural hazards and notify occupant
• Identify substance hazards (e.g., mold, lead, asbestos, radon) and notify occupant
  • Test vermiculite in attic for potential asbestos.
  • If assessor is likely to recommend heating system repairs or removal that may disturb potential asbestos on piping, test material to determine if asbestos is present.
  • If there is an attached or tuck-under garage, identify the location of air leaks from the garage to occupied spaces.
  • Identify evidence of pests (e.g., feces, urine stains, chew marks).
  • Determine if painted surfaces to be disturbed may contain lead-based paint (e.g., painted surfaces in pre-1978 homes unless testing confirms non lead-based paint).
• Test for radon. If levels exceed EPA action level of 4pCi/L, ensure energy efficiency retrofit work does not increase radon levels. Confirm in post-retrofit radon test.
• Verify existence and operation of smoke and CO alarms

**Occupant Education**
- Provide occupants with a reasonable estimation of energy savings
- Advise occupants on additional baseload reduction strategies
- Educate occupants on additional energy reduction strategies and actions
- Educate occupants on any hazards and appropriate steps to address them

**Industry Home Assessment Standards Condensed**

**Combustion Appliance Safety:**
- Fuel leaks
- Clearance to combustibles
- Ambient carbon monoxide (CO)
- CO in undiluted flue gases
- CO on gas cook stoves
- Depressurization test
- Combustion air
- Safety shut offs
- Heat exchanger
- Unvented space heaters
- Inspect venting systems for damage, leaks, disconnections and other safety hazards
- Spillage and draft testing
- Combustion Appliance Zone (CAZ) Safety Inspection - Make sure there are no flammable or explosive materials near any combustion source

**Existing and Potential Moisture Problems:**
- Exterior water intrusion
- Interior moisture sources
- Condition of downspouts, flashing, etc.
- Presence of properly applied vapor retarders

**Mechanical Ventilation Needs:**
- Flow capacity of existing mechanical ventilation
- ASHRAE 62.2-2010
- Verify flows of all exhaust fans (including dryer) and venting to outdoors
- Note presence and operability of whole-house fans and powered-attic-ventilators and discuss with occupant
- Note presence, location and operability of exhaust fans and determine whether they are vented outside
- If attached garage, note whether exhaust fan is present and operable
- Electrical hazards
- Fire or structural hazards
- Substance hazards
- Mold
- Lead
- Asbestos
- Radon
- Existence and operation of smoke and CO alarms
- Connectivity between house and attached garage
- Measure selection
- Cost benefit analysis
- Department of Energy (DOE)-approved audit
- Use of consumption data to target high energy usage
- Use of priority lists

**Building Shell:**
- Note key features of house (e.g., porch roof, multiple roof lines, cantilevers, bay windows, dormers, knee wall attics, attic access, house additions)
- Check attic venting
- Check for signs of moisture damage (e.g., stains, soft or rotted materials, damaged insulation)
- Inspect house for renewable energy opportunities

**Air Leakage:**
- Blower door testing
- When not to use blower door testing
- Zonal pressure diagnostics
- When not to seal
- Prioritized sealing
- Cost effective sealing guidelines
- Infrared (IR) scanning

**Conductive Losses:**
- R-value of opaque building materials and cavities
- U-factors and solar heat gain coefficients of windows
- Feasibility of additional insulation
- Cost effectiveness of insulation retrofits or window replacements
- Cost effectiveness of shading and reflective coatings
- Envelope thermal characteristics - Determining thermal boundary
- Identify thermal bypasses
HEATING AND COOLING EFFICIENCY

Furnace performance and efficiency:
- Cleaning
- Tuning
- Adjustment
- Control upgrades

Boiler performance and efficiency:
- Cleaning
- Tuning
- Adjustment
- Control upgrades

Air-condition and heat pump performance and efficiency:
- Cleaning
- Tuning
- Adjustment
- Control upgrades

Steam and hot water space heating distribution efficiency:
- Cleaning
- Tuning
- Adjustment
- Control upgrades

Duct performance:
- Pressure pan testing
- Room pressure imbalances
- Temperature rise test
- Static pressure test
- Duct pressurization test
- Dominant duct leakage test
- Duct location and R-value
- Feasibility and cost effectiveness of retrofit duct insulation
- Evaluation of filter effectiveness and duct sizing
- Visual inspection of ducts for leaks, disconnects, crimps, signs of moisture, return leaks near combustion equipment, damage or other atypical conditions
- Evaporative cooler maintenance, installation and performance
- Heating, ventilation and air conditioning (HVAC) equipment replacement criteria and sizing
Base load:
- Occupant education
- Domestic hot water (DHW)
- Refrigerator performance
- Lighting efficiency
- Clothes dryer venting
- Pool and spa energy consumption and conservation strategies
- For all appliances greater than 10 years old, discuss benefits of replacing them with ENERGY STAR® qualified appliances

DEFERRAL OF WAP SERVICES

Miscellaneous Additions:
- Interview with occupant
- Provide disclosure of conflicts of interest to occupant
- Inform occupants of low cost and no cost improvements that they can implement
- Provide a scope of work
- Advise the occupant on where to locate qualified individuals and contractors to complete the work on the home
- Pre-work and post-work verification/test-out
- Visual Inspection of HVAC and DHW
- Determine number and type of t-stats
- Verify system information: age, model, heat in/out, capacity, general condition and maintenance history
- Check for evidence of backdraft, flame roll-out, blocked chimney and corroded or missing vent connector
- If boiler, verify that pressure relief valve is present and not obstructed
- If condensing unit, check the condensate line for signs of blockage or leaks
- Check exhaust vent for proper fitting and termination
- Check for issues around compressor or fan in yard such as air flow obstruction
- Check for insulation on refrigerant line set
- Inspect air filters
- Verify secondary overflow pans and presence of condensation drain line or float disconnect switch
- Note any ducts or air handlers in garages
- For hydronic systems, note insulation values and opportunity for pipe insulation
- For baseboards, note condition and positioning of covers, presence of dust, webs or other material on the fins
- Note temperature setting on water heater
- Signs of water leakage on DHW tank
- Inspect water heater and pipes for efficiency improvements (e.g., presence or lack of insulation, convective loop, feasibility of retrofitting insulation on tank or pipes)
• Specifications given for a summary report to be given to the occupant (example reports given)

Additions from Visual Inspection of home:
• Note square footage and approximate age of house
• Types of windows - glazing type and frame material
• Type of foundation
• Estimated age of major appliances (e.g., dishwashers, refrigerators, freezers, washing machines, dryers)
• General Limitations: The energy use information contained in the report does not constitute any warranty of energy cost or savings
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<td>For all appliances greater than 10 years old, discuss benefits of replacing them with ENERGY STAR® qualified appliances</td>
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<td>Provide disclosure of conflicts of interest to occupant</td>
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<td>Inform the occupant of low cost and no cost improvements they can implement</td>
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<td>Advise the occupant on where to locate qualified individuals and contractors to complete the work on the house</td>
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<td>Determine number, type and location of thermostats</td>
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<td>Verify system information: age, model, heat in/out, capacity, general condition and maintenance history</td>
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<td>Check for evidence of backdraft, flame roll-out, blocked chimney and corroded or missing vent connector</td>
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<td>If boiler, verify that pressure relief valve is present and not obstructed</td>
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<td>If condensing unit, check the condensate line for signs of blockage or leaks</td>
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<td>Check exhaust vent for proper fitting and termination</td>
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<td>Check for issues around compressor or fan in yard such as air flow obstruction</td>
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<td>Check for insulation on refrigerant line set</td>
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<td>Inspect air filters</td>
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<td>Verify secondary overflow pans and presence of condensation drain line or float disconnect switch</td>
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<td>Note any ducts or air handlers in garages</td>
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<td>For hydronic systems, note insulation values and opportunity for pipe insulation</td>
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<td>For baseboards systems, note condition and positioning of covers, presence of dust, webs or other material on the fins</td>
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<td>Signs of water leakage on DHW tank</td>
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<td>Inspect water heater and pipes for efficiency improvements (e.g., presence or lack of insulation, convective loop, feasibility of retrofitting insulation on tank or pipes)</td>
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<td>Specifications given for a summary report to be given to the occupant (example reports given)</td>
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<td><strong>Additions from Visual Inspection of House</strong></td>
<td>Note square footage and approximate age of house</td>
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<td>Types of windows - glazing type and frame material</td>
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<td>Type of foundation</td>
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<td>Estimated age of major appliances (e.g., dishwashers, refrigerators, freezers, washing machines, dryers)</td>
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<td>General limitations: The energy use information contained in the report does not constitute any warranty of energy cost or savings</td>
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</table>
SECTION 2: COMBUSTION APPLIANCES

Table of Contents

Health and Safety

Safe Work Practices: ¹
1) Combustion Worker Safety

Combustion Appliance Zone (CAZ) Testing:
2) Depressurization Test
3) Spillage Test
4) Draft Test
5) Carbon Monoxide Test
6) Gas Leak Detection

Combustion Appliances

Unvented Space Heaters:
7) Propane, Natural Gas and Kerosene Heaters

Vented Gas Appliances:
8) Combustion Air for Atmospherically Vented Appliances
9) Combustion Flue Gas – Orphaned Water Heater
10) Draft Regulation – Category I Appliance

Safety Devices:
11) Smoke Detector
12) Carbon Monoxide Detector or Monitor

Appendix B

Combustion Appliance Zone (CAZ) Depressurization Limits Table

¹ Appendix D – OSHA Personal Protective Equipment Standards
Health and Safety

Safe Work Practices:
   1) Combustion Worker Safety

Combustion Appliance Zone (CAZ) Testing:
   2) Depressurization Test
   3) Spillage Test
   4) Draft Test
   5) Carbon Monoxide Test
   6) Gas Leak Detection
### Topic: Health and Safety

#### Subtopic: Safe Work Practices

1) **Detail Name:** Combustion Worker Safety

#### Desired Outcome:
- Work completed safely without injury or hazardous exposure

<table>
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<th>Specification(s)</th>
<th>Objective(s)</th>
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<tbody>
<tr>
<td>1</td>
<td>Hand protection</td>
<td>Durable and wrist protecting gloves will be worn that can withstand work activity</td>
<td>Minimize skin contact with contaminants</td>
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<tr>
<td></td>
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<td>Protect hands from sharp objects</td>
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<tr>
<td>2</td>
<td>Respiratory protection</td>
<td>Respirators appropriate for the contaminants present will be worn (e.g. N-95 or equivalent face mask)</td>
<td>Minimize exposure to airborne contaminants (e.g. insulation materials, mold spores, feces, bacteria, chemicals)</td>
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<td>3</td>
<td>Electrical safety 4,5</td>
<td>An electrical safety assessment will be performed</td>
<td>Avoid electrical shock and arc flash hazards</td>
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<td>Extension cords used with portable electric tools will be of three-wire type</td>
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<td>Worn or frayed electric cords will not be used</td>
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<td>All electric tools will be protected by Ground-Fault Circuit Interrupters 6</td>
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<td>Metal ladders will be avoided</td>
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<td>Water such as condensate pans and electrical sources will be</td>
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2 OSHA Technical Manual Section VIII: Chapter 1, part III
3 OSHA Technical Manual Section VIII: Chapter 2, section IV
5 29 CFR 1926 Subpart K – Electrical
<p>| | | |</p>
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<tr>
<td>kept separate</td>
<td>Special precautions will be taken if knob and tube wiring is present</td>
<td>For arc flash hazards, NFPA 70E will be consulted</td>
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</table>
| 4 | **Protective clothing** | Eye protection will be worn at all times (e.g. safety glasses, goggles if not using full face respirator)  
Protect worker from skin contact with contaminants  
Minimize spread of contaminants |
|   | **Confined space safety** 8,9 | Access and egress points will be located before beginning work  
Inspection will be conducted for frayed electrical wires  
Adequate ventilation will be provided  
Use of toxic material will be reduced  
Prevent build-up of toxic or flammable contaminants  
Provide adequate access and egress  
Avoid electrical shock |
| 6 | **Power tool safety** 10 | Power tools will be inspected and used according to manufacturer specifications to eliminate hazards associated with missing ground prongs, ungrounded circuits, misuse of power tools, noise and improper or defective cords or extension cords  
All devices used will be verified as GFI protected or double insulated  
Prevent power tool injuries |

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7 OSHA Technical Manual Section VIII: Chapter 1, part III  
8 ASTM D4276 - 02(2007)  
10 29 CFR 1910 Subpart P - Hand and portable powered tools and other hand-held equipment
| 7 | **Chemical safety** | The least toxic suitable material will be chosen  
    Hazardous materials will be handled according to safety procedures to avoid hazards associated with volatile organic compounds (VOCs), sealants, insulation, dust, foams, asbestos, lead, mercury fibers and oil tank mercury¹¹ | Prevent exposure to toxic substances |
| 8 | **Ergonomic safety**¹² | Proper equipment will be used for work  
    Proper lifting techniques will be used | Avoid injuries from awkward postures, repetitive motions and improper lifting |
| 9 | **Hand tool safety** | Hand tools will be used for intended purpose¹³ | Reduce injuries |
| 10 | **Slips, trips and falls**¹⁴ | Caution will be used around power cords, hoses, tarps and plastic sheeting  
    Precautions will be taken when ladders are used, when working at heights or when balancing on joists  
    Walk boards will be used when practical  
    Appropriate footwear and clothing will be worn | Eliminate injuries due to slips, trips and falls |

¹¹ 29 CFR 1910 Subpart Z - Toxic and Hazardous Substances  
¹³ 29 CFR 1910 Subpart P - Hand and portable powered tools and other hand-held equipment  
¹⁴ 29 CFR 1926 Subpart M - Fall Protection
<table>
<thead>
<tr>
<th></th>
<th><strong>Heat and thermal stress</strong>&lt;sup&gt;15&lt;/sup&gt;</th>
<th>Appropriate ventilation, hydration, rest breaks and cooling equipment will be used. Dial 911 when necessary</th>
<th>Reduce heat stroke, heat stress and cold stress related injuries</th>
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<tbody>
<tr>
<td>12</td>
<td><strong>Prevention through design</strong></td>
<td>Design will be incorporated to eliminate or minimize hazards (e.g. material selection, access to equipment for installation and maintenance, placement of equipment, duct work and condensate lines)&lt;sup&gt;16&lt;/sup&gt;</td>
<td>Prevent worker injuries, exposure to toxic substances and physical hazards</td>
</tr>
</tbody>
</table>

<sup>15</sup> 29 CFR 1926 Subpart C - General Safety and Health Provisions

<sup>16</sup> 29 CFR 1926 Subpart C - General Safety and Health Provisions
### Topic: Health and Safety

#### Subtopic: Combustion Appliance Zone (CAZ) Testing

2) **Detail Name:** Depressurization Test

**Desired Outcome:**
- Combined effect of mechanical system fans on combustion zone pressure measured

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Duct leakage</td>
<td>Furnace, heat pump and air conditioner fan will be on the high speed setting</td>
<td>Account for all pressure change caused by dominant duct leakage to outside or inside.</td>
</tr>
<tr>
<td>2</td>
<td>Interior door closure</td>
<td>Bedroom doors will be closed and the direction of air flow will be checked</td>
<td>Account for all pressure change caused by door closure.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Door closure will be included in worst-case testing</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Exhaust and supply fans smaller than 150 cubic feet per minute (CFM)</td>
<td>Bath, kitchen, laundry room, dryer, attic, crawl space and ventilation (exhaust and supply) fans will be included in depressurization testing</td>
<td>Account for all pressure change caused by all exhaust fans, dryers and supply fans.</td>
</tr>
<tr>
<td>4</td>
<td>Depressurization limits</td>
<td>The combined effect of the above mechanical air distribution fans creating the lowest pressure conditions will not exceed negative pressures listed in the Combustion Appliance Zone Depressurization Limits Table (Appendix B)</td>
<td>Reduce the occurrence of backdrafting, pressure induced flame roll-out, carbon monoxide production and prolonged spillage of flue gasses.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The limits will be according to the venting conditions listed in the same table</td>
<td></td>
</tr>
</tbody>
</table>

17 ASTM E1554 - 07
**Topic: Health and Safety**  
**Subtopic: Combustion Appliance Zone (CAZ) Testing**

3) **Detail Name:** Spillage Test

**Desired Outcome:**
- Accurate information about spillage of combustion gasses gathered

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Spillage test</td>
<td>Combustion gasses will not spill out of the draft diverter for more than 1 minute</td>
<td>Detect excessive spillage of combustion gasses 19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>upon firing a furnace or water heater under lowest pressure conditions</td>
<td></td>
</tr>
</tbody>
</table>

Topic: Health and Safety
Subtopic: Combustion Appliance Zone (CAZ) Testing

4) **Detail Name:** Draft Test

**Desired Outcome:**
- Accurate information about draft pressure gathered

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Separate vent</td>
<td>Furnaces, boilers and water heaters will be tested for carbon monoxide (CO) production after 5 minutes of run time</td>
<td>Reduce the occurrence of appliance backdrafting 20</td>
</tr>
</tbody>
</table>
| 2   | Shared vent   | Shared vent gas or oil furnaces, boilers and water heaters will be draft tested after 5 minutes of run time  
The lowest British thermal unit (Btu) appliance will be tested first and allowed to cool before testing the next | Reduce the occurrence of appliance backdrafting at different outside temperatures 21 |
| 3   | Draft pressure| All draft pressures will be equal to or greater than minimum draft pressures listed on the Minimal Acceptable Draft Pressure Table (Appendix B) | Reduce the occurrence of appliance backdrafting at different outside temperatures 21 |

---

Topic: Health and Safety
Subtopic: Combustion Appliance Zone (CAZ) Testing

5) **Detail Name:** Carbon Monoxide Test

**Desired Outcome:**
- Accurate reading of carbon monoxide (CO) production

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Furnaces, boilers and water heaters</td>
<td>Furnaces, boilers and water heaters will be tested for carbon monoxide (CO) production after 5 minutes of run time</td>
<td>Measure CO when the appliance is in steady state</td>
</tr>
<tr>
<td>2</td>
<td>Stoves and ovens</td>
<td>Oven will be tested for CO production after 5 minutes of run time</td>
<td>Measure CO when the oven is at a steady temperature</td>
</tr>
</tbody>
</table>

---

Topic: Health and Safety  
Subtopic: Combustion Appliance Zone (CAZ) Testing

6) Detail Name: Gas Leak Detection

Desired Outcome:
- Accurate information about gas leaks gathered

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Detection | Gas pipes and connections will be tested for leaks at a sensitivity of no less than 20 parts per million $^{24}$ | Detect gas leaks  
Detected leaks will be confirmed with gas leak detection fluid  
Determine need for repair |

$^{24}$ NFPA 54/ANSI/AGA Z223.1
Combustion Appliances

Unvented Space Heaters:
7) Propane, Natural Gas and Kerosene Heaters

Vented Gas Appliances:
8) Combustion Air for Atmospherically Vented Appliances
9) Combustion Flue Gas – Orphaned Water Heater
10) Draft Regulation – Category I Appliance

Safety Devices:
11) Smoke Detector
12) Carbon Monoxide Detector or Monitor
**Topic: Combustion Appliances**

**Subtopic: Unvented Space Heaters**

7) **Detail Name:** Propane, Natural Gas and Kerosene Heaters

**Desired Outcome:**
- Elimination of combustion byproducts

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Removal</td>
<td>Unvented space heaters will be permanently removed from the house before any retrofit</td>
<td>Eliminate sources of combustion byproduct</td>
</tr>
</tbody>
</table>
8) **Detail Name:** Combustion Air for Atmospherically Vented Appliances

**Desired Outcome:**
- Sufficient air provided in the Combustion Appliance Zone (CAZ)

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CAZ pressure testing</td>
<td>The Building Performance Institute (BPI) protocol or equivalent for CAZ combustion safety testing will be administered.</td>
<td>Ensure appliance is drafting properly</td>
</tr>
<tr>
<td>2</td>
<td>Required combustion air</td>
<td>Volume of air required for complete combustion of the fuel and air mixture will be calculated in cubic feet per minute (CFM) according to ANSI and NFPA guidelines.</td>
<td>Determine if existing conditions meet the combustion air calculation</td>
</tr>
<tr>
<td>3</td>
<td>Additional combustion air (if action is required)</td>
<td>Additional combustion air will be provided according to ANSI and NFPA guidelines</td>
<td>Ensure adequate combustion air for operation of the appliance</td>
</tr>
<tr>
<td>4</td>
<td>Occupant health</td>
<td>Carbon monoxide (CO) monitors will be provided in all houses with non-sealed direct vent appliances. Ambient CO will be maintained at or less than acceptable levels after work is complete.</td>
<td>Ensure occupant health and safety</td>
</tr>
</tbody>
</table>

---

26 NFPA 54/ANSI/AGA Z223.1  
27 NFPA 720
**Topic: Combustion Appliances**

**Subtopic:** Vented Gas Appliances

9) **Detail Name:** Combustion Flue Gas – Orphaned Water Heater

**Desired Outcome:**
- Flue gasses successfully removed from the house

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Combustion Appliance Zone (CAZ) pressure testing</td>
<td>The Building Performance Institute (BPI) protocol or equivalent for CAZ combustion safety testing will be administered 28</td>
<td>Determine if applicable appliance is drafting properly and CAZ is safe to work in</td>
</tr>
<tr>
<td>2</td>
<td>Flue gas removal (chimney liner or approved methods)</td>
<td>A chimney liner will be installed according to NFPA 54 fuel code or other approved methods (e.g., power vented, sealed non-power vented combustion) 29</td>
<td>Allow water heater to vent properly and prevent damage to the chimney</td>
</tr>
<tr>
<td>3</td>
<td>Retesting CAZ pressure</td>
<td>The BPI protocol or equivalent for CAZ combustion safety testing will be administered 30</td>
<td>Determine if additional combustion air is needed</td>
</tr>
<tr>
<td>4</td>
<td>Required combustion air 31</td>
<td>Volume of air required for complete combustion of the fuel and air mixture will be calculated in cubic feet per minute (CFM) according to ANSI and NFPA guidelines</td>
<td>Determine if existing conditions meet the combustion air calculation</td>
</tr>
<tr>
<td>5</td>
<td>Additional combustion air (if action is required)</td>
<td>Additional combustion air will be provided according to ANSI and NFPA guidelines 32</td>
<td>Ensure adequate combustion air for operation of the appliance</td>
</tr>
</tbody>
</table>

29 NFPA 31 or NFPA 54/ANSI/AGA Z223.1
31 NFPA 54/ANSI/AGA Z223.1
32 NFPA 54/ANSI/AGA Z223.1
<table>
<thead>
<tr>
<th></th>
<th>Occupant health</th>
<th>Carbon monoxide (CO) monitors will be provided in all houses with non-sealed direct vent appliances. Ambient CO will be maintained at or less than acceptable levels after work is complete.</th>
<th>Ensure occupant health and safety</th>
</tr>
</thead>
</table>

33 NFPA 720
## Topic: Combustion Appliances

**Subtopic:** Vented Gas Appliances

10) **Detail Name:** Draft Regulation – Category I Appliance

**Desired Outcome:**
- Buildup of flue gasses prevented through proper drafting

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Assessment</td>
<td>The presence of an operable draft regulator will be verified (e.g., diverter, hood, barometric damper) (^{34})</td>
<td>Determine if a regulator is present and working</td>
</tr>
<tr>
<td>2</td>
<td>Installation (if action is required)</td>
<td>A draft regulator will be installed if necessary (^{35})</td>
<td>Install regulator according to manufacturer specifications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manufacturer specifications for installation will be followed (e.g., size, type, location) (^{36})</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Calibration</td>
<td>A draft gauge will be used to calibrate regulation (^{37})</td>
<td>Ensure draft meets manufacturer specifications</td>
</tr>
<tr>
<td>4</td>
<td>Combustion Appliance Zone (CAZ) pressure testing</td>
<td>The Building Performance Institute (BPI) protocol or equivalent for CAZ combustion safety testing will be administered (^{38})</td>
<td>Ensure that applicable appliance does not backdraft or spill</td>
</tr>
<tr>
<td>5</td>
<td>Occupant health</td>
<td>Carbon monoxide (CO) monitors will be installed in all houses with Category I appliances</td>
<td>Ensure occupant health and safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ambient CO will be maintained at or less than</td>
<td></td>
</tr>
</tbody>
</table>

\(^{34}\) NFPA 54/ANSI/AGA Z223.1  
\(^{35}\) NFPA 54/ANSI/AGA Z223.1  
\(^{36}\) NFPA 31 or NFPA 54/ANSI/AGA Z223.1  
\(^{37}\) NFPA 54/ANSI/AGA Z223.1  
\(^{38}\) NFPA 54/ANSI/AGA Z223.1
<table>
<thead>
<tr>
<th></th>
<th></th>
<th>acceptable levels after work is complete&lt;sup&gt;39&lt;/sup&gt;</th>
</tr>
</thead>
</table>
| 6 | **Occupant education** | Occupants will be educated on the operation and maintenance of the CO monitor<sup>40</sup>  
Completed work and recommended maintenance will be reviewed | Ensure occupant can operate and maintain installations |

<sup>39</sup> NFPA 720  
<sup>40</sup> NFPA 720
**Topic: Combustion Appliances**  
**Subtopic: Safety Devices**

11) **Detail Name:** Smoke Detector

**Desired Outcome:**
- Properly installed smoke detectors

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Smoke alarm (hard-wired)</td>
<td>Hard-wired smoke alarms will be installed according to NFPA standards 41</td>
<td>Ensure proper installation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Installation will be accomplished by a licensed electrician</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Smoke alarm (battery operated)</td>
<td>Battery operated alarms will be installed according to manufacturer specifications 42</td>
<td></td>
</tr>
</tbody>
</table>

41 NFPA 54/ANSI/AGA Z223.1  
42 NFPA 720
**Topic: Combustion Appliances**  
**Subtopic: Safety Devices**

12) **Detail Name:** Carbon Monoxide Detector or Monitor

**Desired Outcome:**
- Properly installed carbon monoxide (CO) detectors or monitors

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Carbon monoxide (CO) detector or monitor (hard-wired) | Hard-wired carbon monoxide detector or monitor will be installed according to NFPA standards<sup>43</sup>  
                  Installation will be accomplished by a licensed electrician            | Ensure proper installation       |
| 2   | Carbon monoxide detector or monitor (battery operated) | Battery operated carbon monoxide detector or monitor will be installed according to manufacturer specifications<sup>44</sup> |                                    |

<sup>43</sup> NFPA 720  
<sup>44</sup> NFPA 720
## APPENDIX B

### COMBUSTION APPLIANCE ZONE (CAZ) DEPRESSURIZATION LIMITS

<table>
<thead>
<tr>
<th>VENTING CONDITION</th>
<th>LIMIT (PA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orphan natural draft water heater (including outside chimneys)</td>
<td>-2.0</td>
</tr>
<tr>
<td>Natural draft boiler or furnace commonly vented with water heater</td>
<td>-3.0</td>
</tr>
<tr>
<td>Individual natural draft boiler or furnace</td>
<td>-5.0</td>
</tr>
<tr>
<td>Induced draft boiler or furnace commonly vented with water heater</td>
<td>-5.0</td>
</tr>
<tr>
<td>Power vented, induced draft boiler, furnace alone or fan assisted DHW alone</td>
<td>-15.0</td>
</tr>
<tr>
<td>Chimney-top draft inducer; exhaust type or equivalent; high static pressure flame retention head oil burner; direct vented appliances; sealed combustion appliances</td>
<td>-50.0</td>
</tr>
</tbody>
</table>
SECTION 3: VENTILATION

Table of Contents

Health and Safety

Safe Work Practices: ¹
  1) Ventilation Worker Safety

Exhaust

Components:
  2) Ducts
  3) Terminations
  4) Exhaust Grille Location

Fans:
  5) Surface Mounted Ducted
  6) Inline
  7) Direct Vent
  8) Multi-Port System
  9) Garage Exhaust Fan

Appliance Exhaust Vents:
  10) Clothes Dryer
  11) Kitchen Range

Special Considerations:
  12) Regional Considerations

Supply

Components:
  13) Supply Register Location
  14) Intakes
  15) Ducts for Supply
  16) Intake to Forced Air System

¹ Appendix D – OSHA Personal Protective Equipment Standards
Fans:
17) Inline or Multi-Port

Special Considerations:
18) Regional Considerations

Whole House Ventilation:

Air Flow Requirements:
19) Installed System Air Flow
20) Primary Ventilation Air Flow Between Rooms

Other Components:
21) Controls
22) Heat Recovery Ventilation (HRV) and Energy Recovery Ventilator (ERV) Installation

Dehumidifiers:
23) Stand Alone
24) Ventilator

Special Considerations:
25) Regional Considerations
26) Hot and Humid Climate Impact
27) Sound Rating Limits

Appendix C:

Supplemental Ventilation Information
Health and Safety

Safe Work Practices:

1) Ventilation Worker Safety
### Topic: Health and Safety

#### Subtopic: Safe Work Practices

1) **Detail Name:** Ventilation Worker Safety

**Desired Outcome:**
- Work completed safely without injury or hazardous exposure

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hand protection</td>
<td>Durable gloves that can withstand work activity will be worn ²</td>
<td>Minimize skin contact with contaminants</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Protect hands from sharp objects</td>
</tr>
<tr>
<td>2</td>
<td>Respiratory protection</td>
<td>Respirators appropriate for the contaminants present will be worn (e.g. N-95 or equivalent face mask) ³</td>
<td>Minimize exposure to airborne contaminants (e.g. insulation materials, mold spores, feces, bacteria, chemicals)</td>
</tr>
<tr>
<td>3</td>
<td>Electrical safety ⁴ ⁵</td>
<td>An electrical safety assessment will be performed</td>
<td>Avoid shock and arc flash hazards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All electric tools will be protected by Ground-Fault Circuit Interrupters ⁶</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Extension cords used with portable electric tools will be of three-wire type</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Worn or frayed electric cords will not be used</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metal ladders will be avoided</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water such as condensate pans and electrical sources will be kept separate</td>
<td></td>
</tr>
</tbody>
</table>

² OSHA Technical Manual Section VIII: Chapter 1, part III
³ OSHA Technical Manual Section VIII: Chapter 2, section IV
⁵ 29 CFR 1926 Subpart K – Electrical
<table>
<thead>
<tr>
<th></th>
<th><strong>Protective clothing</strong> 7</th>
<th></th>
<th><strong>Confined space safety</strong> 8,9</th>
<th></th>
<th><strong>Power tool safety</strong> 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>If contaminants are present, (e.g. insulation materials) removable protective clothing will be worn. Eye protection will be worn at all times (e.g. safety glasses, goggles if not using full face respirator). Protect worker from skin contact with contaminants (e.g. insulation materials)</td>
<td></td>
<td>Access and egress points will be located before beginning work. Inspection will be conducted for frayed electrical wires. Adequate ventilation will be provided. Use of toxic material will be reduced. Prevent build-up of toxic or flammable contaminants. Provide adequate access and egress. Avoid electrical shock.</td>
<td></td>
<td>Power tools will be inspected and used according to manufacturer specifications to eliminate hazards associated with missing ground prongs, ungrounded circuits, misuse of power tools, noise and improper or defective cords or extension cords. All devices used will be verified as GFI protected or double insulated. Exhaust gases from compressors and generators will be prevented from entering crawl space. Prevent power tool injuries.</td>
</tr>
</tbody>
</table>

---

7 Appendix D – OSHA Personal Protective Equipment Standards
8 ASTM D4276 - 02(2007)
10 29 CFR 1910 Subpart P - Hand and portable powered tools and other hand-held equipment
<table>
<thead>
<tr>
<th></th>
<th>Safety Category</th>
<th>Description</th>
<th>Prevention/Elimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Chemical safety</td>
<td>The least toxic suitable material will be chosen. Hazards associated with VOCs, sealants, insulation, contaminated drywall, dust, foams, asbestos, lead, fibers, defective or improperly used respirator and Personal Protective Equipment (PPE) will be eliminated.</td>
<td>Prevent toxic exposure to workers</td>
</tr>
<tr>
<td>8</td>
<td>Ergonomic safety</td>
<td>Personal Protective Equipment will be used (e.g. knee pads, bump caps, additional padding).</td>
<td>Avoid injuries with awkward postures and repetitive motions</td>
</tr>
<tr>
<td>9</td>
<td>Hand tool safety</td>
<td>Hand tools will be used for intended purpose.</td>
<td>Reduce injuries</td>
</tr>
<tr>
<td>10</td>
<td>Slips, trips and falls</td>
<td>Caution will be used around power cords, hoses, tarps and plastic sheeting. Precautions will be taken when ladders are used, when working at heights or when balancing on joists. Appropriate footwear and clothing will be worn.</td>
<td>Eliminate injuries due to slips, trips and falls</td>
</tr>
<tr>
<td>11</td>
<td>Heat and thermal stress</td>
<td>Appropriate ventilation, hydration, rest breaks and cooling equipment will be used. Dial 911 when necessary.</td>
<td>Reduce heat stroke, heat stress and cold stress related injuries</td>
</tr>
</tbody>
</table>

11. 29 CFR 1910 Subpart Z - Toxic and Hazardous Substances
13. 29 CFR 1910 Subpart P - Hand and portable powered tools and other hand-held equipment
14. 29 CFR 1926 Subpart M - Fall Protection
15. 29 CFR 1926 Subpart C - General Safety and Health Provisions
| 12 | **Prevention through design** | Design will be incorporated to eliminate or minimize hazards (e.g. material selection, access to equipment for installation and maintenance, placement of equipment, duct work and condensate lines) \(^{16}\) | Prevent worker injuries, exposure to toxic substances and physical hazards |
Exhaust

Components:
2) Ducts
3) Terminations
4) Exhaust Grille Locations

Fans:
5) Surface Mounted Ducted
6) Inline
7) Direct Vent
8) Multi-Port System
9) Garage Exhaust Fan

Appliance Exhaust Vents:
10) Clothes Dryers
11) Kitchen Range

Special Considerations:
12) Regional Considerations
**Topic: Exhaust**  
**Subtopic: Components**

2) **Detail Name:** Ducts

**Desired Outcome:**
- Installed ducts effectively move the required volume of air and prevent condensation

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Duct design and configuration 17 | Ducts will be smooth, will have the shortest run as possible and will have no more than one elbow of a maximum of 90°  
Duct diameter will be equal to or greater than the exhaust fan outlet  
Up to 2’ of flexible duct will be permitted to accommodate tight spaces and reduce noise | Effectively move the required volume of air |
| 2   | Duct insulation | Ducts installed outside of the thermal envelope will be insulated to a minimum of R-8 or equivalent to local codes | Prevent condensation from forming or collecting inside of the duct work |
| 3   | Duct support 18 | Horizontal runs will be supported at intervals of 4’ or less  
Supports with a width of at least 1 ½” will be used | Effectively move the required volume of air  
Preserve the integrity of the duct system |

17 SMACNA HVAC Duct Construction Standard  
18 SMACNA HVAC Duct Construction Standard
| 4 | Duct connections ¹⁹ | Metal-to-metal or metal-to-PVC will be fastened with a minimum of three equally spaced screws  
Flexible duct-to-metal or flexible duct-to-PVC will be fastened with tie bands using a tie band tensioning tool  
Flexible duct between tie band and end of metal or PVC duct will be screwed into place  
PVC-to-PVC materials will be fastened with approved PVC cement  
Other specialized duct fittings will be fastened according to manufacturer specifications  
In addition to mechanical fasteners, seal duct connections with UL 181B or 181B-M listed material |
|---|---|---|
| 5 | Duct materials ²⁰ | Flexible materials will be UL 181 listed or Air Diffusion Council approved  
Rigid, smooth metal of 30-gage wall thickness or thicker will be used on kitchen fans |

¹⁹ SMACNA HVAC Duct Construction Standard  
²⁰ SMACNA HVAC Duct Construction Standard
**Topic: Exhaust**  
**Subtopic: Components**

3) **Detail Name:** Terminations

**Desired Outcome:**
- Termination fittings with unrestricted air flow securely installed

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hole in building shell</td>
<td>A hole as small as possible will be cut to accommodate termination fitting</td>
<td>Allow for ease of weatherproofing</td>
</tr>
<tr>
<td>2</td>
<td>Termination fitting</td>
<td>A termination fitting with an integrated collar will be used</td>
<td>Effectively move the required volume of air to the outside</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collar will be at least the same diameter as the exhaust fan outlet</td>
<td>Preserve integrity of the building envelope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fitting will be appropriate for regional weather conditions and installation location on house</td>
<td>Ensure durable installation</td>
</tr>
<tr>
<td>3</td>
<td>Duct to termination connection 21</td>
<td>Duct will be connected to termination fitting and will be sealed according to duct exhaust detail</td>
<td>Effectively move the required volume of air to the outside</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fasteners will not inhibit damper operation</td>
<td>Preserve integrity of the building envelope</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ensure durable installation</td>
</tr>
<tr>
<td>4</td>
<td>Weatherproof installation</td>
<td>Exterior termination fitting will be flashed or weather sealed</td>
<td>Preserve integrity of the building envelope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water will be directed away from penetration</td>
<td>Ensure a weather tight and durable termination installation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Installation will not inhibit damper operation</td>
<td>Ensure unrestricted air flow</td>
</tr>
</tbody>
</table>

21 SMACNA HVAC Duct Construction Standard
<table>
<thead>
<tr>
<th></th>
<th><strong>5</strong> Pest exclusion</th>
<th>Manufacturer specifications will be followed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Screen material with no less than ¼” and no greater than ½” hole size in any direction will be used</td>
<td>Prevent pest entry</td>
</tr>
<tr>
<td></td>
<td>Installation will not inhibit damper operation or restrict air flow</td>
<td>Ensure proper air flow</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th><strong>6</strong> Termination location</th>
<th>Terminations will be installed:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• 3’ from any property line</td>
<td>Prevent exhaust from reentering house</td>
</tr>
<tr>
<td></td>
<td>• 3’ from operable opening to houses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 10’ from mechanical inlets</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th><strong>7</strong> Kitchen exhaust</th>
<th>Metal or other approved material will be used for termination fitting for kitchen exhaust</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prevent a fire hazard</td>
<td></td>
</tr>
</tbody>
</table>

---

22 ANSI/ASHRAE Standard 62.2-2010
23 ANSI/ASHRAE Standard 62.2-2010
24 ANSI/ASHRAE Standard 62.2-2010
**Topic: Exhaust**  
**Subtopic: Components**

4) **Detail Name:** Exhaust Grille Location

**Desired Outcome:**
- Exhaust grille location optimizes either primary or spot ventilation

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Primary whole house when other spot ventilation is present</strong></td>
<td>Grille will be installed in a central location within the main body of the house</td>
<td>Provide whole house air exchange</td>
</tr>
<tr>
<td>2</td>
<td><strong>Spot ventilation</strong></td>
<td>Grille will be installed in the space where contaminants are generated</td>
<td>Remove contaminated air at the source</td>
</tr>
</tbody>
</table>
| 3   | **Primary whole house when no spot ventilation is present** | Grille will be installed in a central bathroom with the highest moisture generation (consider occupant input) | Remove moisture and odors from the bathroom  
                                              |                                                                                  | Provide whole house air exchange                                    |
## Topic: Exhaust

### Subtopic: Fans

5) **Detail Name:** Surface Mounted Ducted

**Desired Outcome:**
- Surface mounted ducted fans installed to specification

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hole through interior surface</td>
<td>A hole as small as possible will be cut to accommodate fan assembly</td>
<td>Ensure a secure installation</td>
</tr>
<tr>
<td>2</td>
<td>Wiring</td>
<td>Wiring will be installed by a licensed electrician in accordance with local codes and manufacturer specifications</td>
<td>Prevent an electrical hazard</td>
</tr>
<tr>
<td>3</td>
<td>Fan mounting</td>
<td>Fan outlet will be oriented toward the final termination location&lt;br&gt;Fan will be mounted securely according to manufacturer specifications</td>
<td>Ensure short duct run to achieve optimum air flow&lt;br&gt;Ensure a secure installation&lt;br&gt;Ensure fan housing does not shake, rattle or hum when operating</td>
</tr>
<tr>
<td>4</td>
<td>Duct to fan connection</td>
<td>Duct to fan outlet will be connected and sealed according to duct exhaust detail</td>
<td>Exhaust to outside</td>
</tr>
<tr>
<td>5</td>
<td>Fan housing seal 25</td>
<td>Gaps and holes in fan housing will be sealed&lt;br&gt;Sealants will be compatible with their intended surfaces&lt;br&gt;Sealants will be continuous and meet</td>
<td>Prevent air leakage through fan housing&lt;br&gt;Ensure a permanent seal&lt;br&gt;Prevent a fire hazard</td>
</tr>
</tbody>
</table>

25 ASTM C1193 - 09
<table>
<thead>
<tr>
<th></th>
<th>Fire Barrier Specifications</th>
<th>Sealants will be compatible with their intended surfaces</th>
<th>Sealants will be continuous and meet fire barrier specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Fan to interior surface seal</td>
<td>Air flows will match the system’s intent</td>
<td>Exhaust sufficient air from desired locations to outside</td>
</tr>
<tr>
<td>7</td>
<td>Air flow</td>
<td>Air flows will match the system’s intent</td>
<td>Exhaust sufficient air from desired locations to outside</td>
</tr>
<tr>
<td>8</td>
<td>Preventing air leakage</td>
<td>Leakage to the house from other spaces will be prevented (e.g., garages, unconditioned crawl spaces, unconditioned attics)</td>
<td>Protect occupant health and safety</td>
</tr>
<tr>
<td>9</td>
<td>Combustion safety</td>
<td>Pressure effects will be assessed and corrected on drafting for all natural draft combustion appliances as necessary</td>
<td>Ensure safe operation of combustion appliances</td>
</tr>
</tbody>
</table>

26 ASTM C1193 - 09
27 ASTM C1193 - 09
**Topic: Exhaust**  
**Subtopic: Fans**

6) **Detail Name:** Inline

**Desired Outcome:**
- Inline fans installed to specification

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wiring</td>
<td>Wiring will be installed by a licensed electrician in accordance with local codes and manufacturer specifications</td>
<td>Prevent an electrical hazard</td>
</tr>
<tr>
<td>2</td>
<td>Access</td>
<td>Fan and service switch will be accessible for maintenance</td>
<td>Achieve entire system accessibility for maintenance</td>
</tr>
</tbody>
</table>
| 3   | Fan mounting     | Fan outlet will be oriented toward the final termination location  
Fan will be mounted securely according to manufacturer specifications  
Fan will be isolated from the building framing unless specifically designed to be directly attached  
Fan will be installed remotely by installing ducting from intake grille  
  
Fan outlet will be oriented toward the final termination location  
Fan will be mounted securely according to manufacturer specifications  
Fan will be isolated from the building framing unless specifically designed to be directly attached  
Fan will be installed remotely by installing ducting from intake grille  
  
Fan outlet will be oriented toward the final termination location  
Fan will be mounted securely according to manufacturer specifications  
Fan will be isolated from the building framing unless specifically designed to be directly attached  
Fan will be installed remotely by installing ducting from intake grille  
  
Fan outlet will be oriented toward the final termination location  
Fan will be mounted securely according to manufacturer specifications  
Fan will be isolated from the building framing unless specifically designed to be directly attached  
Fan will be installed remotely by installing ducting from intake grille  
  
Fan outlet will be oriented toward the final termination location  
Fan will be mounted securely according to manufacturer specifications  
Fan will be isolated from the building framing unless specifically designed to be directly attached  
Fan will be installed remotely by installing ducting from intake grille  
  
Fan outlet will be oriented toward the final termination location  
Fan will be mounted securely according to manufacturer specifications  
Fan will be isolated from the building framing unless specifically designed to be directly attached  
Fan will be installed remotely by installing ducting from intake grille  
  | Ensure short duct run to achieve optimum air flow  
Ensure fan is installed securely  
Ensure fan housing or building framing does not shake, rattle or hum when operating  
Minimize noise  
  
Ensure short duct run to achieve optimum air flow  
Ensure fan is installed securely  
Ensure fan housing or building framing does not shake, rattle or hum when operating  
Minimize noise  
  
Ensure short duct run to achieve optimum air flow  
Ensure fan is installed securely  
Ensure fan housing or building framing does not shake, rattle or hum when operating  
Minimize noise  
  
Ensure short duct run to achieve optimum air flow  
Ensure fan is installed securely  
Ensure fan housing or building framing does not shake, rattle or hum when operating  
Minimize noise  
  |                                                                 |                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                           |
| 4   | Backdraft damper | A backdraft damper will be installed between the outlet side of the fan and the exterior  
  
A backdraft damper will be installed between the outlet side of the fan and the exterior  
  
A backdraft damper will be installed between the outlet side of the fan and the exterior  
  
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A backdraft damper will be installed between the outlet side of the fan and the exterior  
  
A backdraft damper will be installed between the outlet side of the fan and the exterior  
  | Prevent reverse air flow when the fan is off                                                                                                           |                                                                                                                                                           |

29 ANSI/ASHRAE Standard 62.2-2010
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 5 | **Duct connections** | Ducts will be connected and sealed to the intake, fan and termination fitting according to duct exhaust detail [30] | Exhaust from desired location to outside  
Preserve integrity of the duct system and building envelope |
| 6 | **Boot to interior surface seal** [31] | Sealants will be compatible with their intended surfaces  
Sealants will be continuous and meet fire barrier specifications | Prevent air leakage around intake housing  
Prevent a fire hazard |
| 7 | **Air flow** | Air flows will match the system’s intent | Exhaust sufficient air from desired locations to outside |
| 8 | **Preventing air leakage** | Leakage to the house from other spaces (e.g., garages, unconditioned crawl spaces, unconditioned attics) will be prevented [32] | Protect occupant health and safety |
| 9 | **Combustion safety** | Pressure effects will be assessed and corrected on drafting for all natural draft combustion appliances as necessary [33] | Ensure safe operation of combustion appliances |

[30] SMACNA HVAC Duct Construction Standard  
[31] ASTM C1193 - 09  
[32] ASTM C1193 - 09  
# Topic: Exhaust

**Subtopic:** Fans

7) **Detail Name:** Direct Vent

**Desired Outcome:**
- Direct vent fans installed to specification

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hole in building shell</td>
<td>A hole as small as possible will be cut to accommodate fan assembly</td>
<td>Ensure a weather tight and secure installation</td>
</tr>
<tr>
<td>2</td>
<td>Wiring</td>
<td>Wiring will be installed by a licensed electrician in accordance with local codes and manufacturer specifications</td>
<td>Prevent an electrical hazard</td>
</tr>
<tr>
<td>3</td>
<td>Fan mounting</td>
<td>Fan outlet will be oriented toward the final termination location</td>
<td>Install mounting fan securely</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fan will be mounted securely according to manufacturer specifications</td>
<td>Ensure fan housing does not shake, rattle or hum when operating</td>
</tr>
<tr>
<td>4</td>
<td>Weatherproof installation</td>
<td>Exterior termination fitting will be flashed or weather sealed (^{34})</td>
<td>Preserve integrity of the building envelope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water will be directed away from penetration</td>
<td>Ensure a weather tight and durable installation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Termination fitting installation will not inhibit damper operation</td>
<td>Ensure unrestricted air flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manufacturer specifications will be followed</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Fan housing seal (^{35})</td>
<td>Sealants will be compatible with their intended surfaces</td>
<td>Prevent air leakage through fan housing</td>
</tr>
</tbody>
</table>

\(^{34}\) ASTM C1193 - 09

\(^{35}\) ASTM C1193 - 09
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sealants will be continuous and meet fire barrier specifications</td>
<td>Ensure a permanent seal to the building air barrier</td>
</tr>
<tr>
<td>6</td>
<td>Fan to interior surface seal 36</td>
<td>Sealants will be compatible with their intended surfaces</td>
</tr>
<tr>
<td></td>
<td>Sealants will be continuous and meet fire barrier specifications</td>
<td>Prevent air leakage around intake housing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prevent a fire hazard</td>
</tr>
<tr>
<td>7</td>
<td>Insulation</td>
<td>All components outside of the thermal envelope will be insulated to a minimum of R-8 or equivalent to local codes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exception: If system operates continuously, fan housing need not be insulated</td>
</tr>
<tr>
<td>8</td>
<td>Preventing air leakage</td>
<td>Leakage to the house from other spaces will be prevented (e.g., garages, unconditioned crawl spaces, unconditioned attics) 37</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Protect occupant health and safety</td>
</tr>
<tr>
<td>9</td>
<td>Combustion safety</td>
<td>Pressure effects will be assessed and corrected on drafting for all natural draft combustion appliances as necessary 38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ensure safe operation of combustion appliances</td>
</tr>
</tbody>
</table>

36 ASTM C1193 - 09  
37 ASTM C1193 - 09  
### Topic: Exhaust

**Subtopic:** Fans

8) **Detail Name:** Multi-Port System

**Desired Outcome:**
- Multi-port fans installed to specification

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wiring</td>
<td>Wiring will be installed by a licensed electrician in accordance with local codes and manufacturer specifications</td>
<td>Prevent an electrical hazard</td>
</tr>
<tr>
<td>2</td>
<td>Access</td>
<td>Fan and service switch will be accessible for maintenance</td>
<td>Achieve designed exhaust flow from desired locations to the outside</td>
</tr>
<tr>
<td>3</td>
<td>Fan mounting</td>
<td>Fan outlet will be oriented toward the final termination location</td>
<td>Ensure short duct runs to achieve optimum air flows</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fan will be mounted securely according to manufacturer specifications</td>
<td>Ensure mounting is installed securely</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fan will be isolated from the building framing unless specifically designed to be directly attached</td>
<td>Ensure fan housing or building framing does not shake, rattle or hum when operating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fan will be installed remotely by ducting from intake grilles</td>
<td>Minimize noise</td>
</tr>
<tr>
<td>4</td>
<td>Backdraft dampers (required in intermittent systems)</td>
<td>A backdraft damper will be installed between the fan and the exterior, unless the system operates continuously 39</td>
<td>Prevent reverse air flow when the system is off</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A backdraft damper will be installed in any duct serving any</td>
<td>Prevent spread of contaminants between rooms</td>
</tr>
</tbody>
</table>

39 ANSI/ASHRAE Standard 62.2-2010
<table>
<thead>
<tr>
<th>5</th>
<th><strong>Combining intake ducts</strong></th>
<th>All individual intake ducts will be combined on the upstream side of fan (e.g., Y, T, Collector Box)</th>
<th>Exhaust air from desired locations to outside</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td><strong>Duct connections</strong> 41</td>
<td>Ducts will be connected and sealed to applicable intakes, collector box, fan and termination fitting</td>
<td>Exhaust air from desired locations to outside</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ducts will be connected and sealed according to duct exhaust detail</td>
<td>Preserve integrity of the duct system and building envelope</td>
</tr>
<tr>
<td>7</td>
<td><strong>Insulation</strong></td>
<td>All components outside of the thermal envelope will be insulated to a minimum of R-8 or equivalent to local codes</td>
<td>Preserve integrity of the duct system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exception: If system operates continuously, fan housing need not be insulated</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><strong>Boot to interior surface seal</strong> 42</td>
<td>Sealants will be compatible with their intended surfaces</td>
<td>Prevent air leakage around boot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sealants will be continuous and meet fire barrier specifications</td>
<td>Ensure a permanent seal to the building air barrier</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Prevent a fire hazard</td>
</tr>
<tr>
<td>9</td>
<td><strong>Air flow</strong></td>
<td>Air flows will match the system’s intent</td>
<td>Exhaust sufficient air from desired locations to outside</td>
</tr>
<tr>
<td>10</td>
<td><strong>Preventing air leakage</strong> 43</td>
<td>Air leakage into the house from other spaces will be prevented (e.g., garages, unconditioned crawl spaces, unconditioned attics)</td>
<td>Protect occupant health and safety</td>
</tr>
</tbody>
</table>

---

40 ANSI/ASHRAE Standard 62.2-2010
41 SMACNA HVAC Duct Construction Standard
42 ASTM C1193 - 09
43 ASTM C1193 - 09
<table>
<thead>
<tr>
<th></th>
<th>Combustion safety</th>
<th>Pressure effects will be assessed and corrected on drafting for all natural draft combustion appliances as necessary ⁴⁴</th>
<th>Ensure safe operation of combustion appliances</th>
</tr>
</thead>
</table>

**Topic: Exhaust**

**Subtopic:** Fans

9) **Detail Name:** Garage Exhaust Fan

**Desired Outcome:**
- Contaminants are properly removed from the house

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>System selection</td>
<td>Ventilation for garage will be exhaust only</td>
<td>Remove contaminants from garage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reduce contaminant migration from garage to house</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Protect occupant health and safety</td>
</tr>
<tr>
<td>2</td>
<td>Air leakage</td>
<td>Air leakage between the house and garages will be prevented</td>
<td>Protect occupant health and safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reduce contaminant migration from garage to house</td>
</tr>
<tr>
<td>3</td>
<td>Combustion safety</td>
<td>Pressure effects will be assessed and corrected on drafting for all natural draft</td>
<td>Ensure safe operation of combustion appliances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>combustion appliances as necessary 45</td>
<td>Protect occupant health and safety</td>
</tr>
</tbody>
</table>

**Topic: Exhaust**  
**Subtopic:** Appliance Exhaust Vents

10) **Detail Name:** Clothes Dryer

**Desired Outcome:**  
- Dryer air is exhausted efficiently and safely

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Clothes dryer ducting      | Clothes dryers will be ducted to outside 46  
As short a run as practical of smooth wall metal duct will be used, following manufacturer specifications and IMC 2009 504  
Ducts will be connected and sealed as described in duct exhaust detail:  
- Sheet metal screws or other fasteners that will obstruct the exhaust flow will not be used  
- Condensing dryers will be plumbed to a drain | Preserve integrity of building envelope  
Effectively move air from clothes dryer to outside |
|   | Termination fitting | Termination fitting approved for use with dryers will be installed. A backdraft damper will be included, as described in termination fitting detail, with the exception of installing a pest exclusion screen.  
47 ANSI/ASHRAE Standard 62.2-2010 |
|---|-------------------|---|
| 3 | Make-up air       | Make-up air will be provided for appliances exhausting more than 200 cubic feet per minute (CFM)  
| 4 | Combustion safety | Pressure effects will be assessed and corrected on drafting for all natural draft combustion appliances as necessary  
Protect occupant health and safety |
| 5 | Occupant education| Occupant will be instructed to keep lint filter and termination fitting clean  
49 ANSI/ASHRAE Standard 62.2-2010 | Effectively move air from clothes dryer to outside |
### Topic: Exhaust
#### Subtopic: Appliance Exhaust Vents

11) **Detail Name:** Kitchen Range

**Desired Outcome:**
- Kitchen range fan installed to specification

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wiring</td>
<td>Wiring will be installed by a licensed electrician in accordance with local codes and manufacturer specification 50</td>
<td>Prevent an electrical hazard</td>
</tr>
<tr>
<td>2</td>
<td>Fan venting</td>
<td>Kitchen range fans will be vented to the outside 51</td>
<td>Remove cooking contaminants from the house</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Re-circulating fans will not be used as a ventilating device</td>
<td>Preserve integrity of building envelope</td>
</tr>
<tr>
<td>3</td>
<td>Fan ducting</td>
<td>Kitchen range fans will be ducted to the outside 52</td>
<td>Preserve integrity of building envelope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>As short a run as practical of smooth wall metal duct will be used, following manufacturer specifications and IMC 2009 505</td>
<td>Effectively move air from range to outside</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ducting will be connected and sealed as described in exhaust duct detail</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Termination fitting</td>
<td>Termination fitting will be installed including a backdraft damper, as described in termination fitting detail 53</td>
<td>Ensure safe operation of combustion appliances</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Protect occupant health and safety</td>
</tr>
</tbody>
</table>

---

50 OSHA Technical Manual Section VIII: Chapter 1, part III
51 ANSI/ASHRAE Standard 62.2-2010
52 ANSI/ASHRAE Standard 62.2-2010
53 ANSI/ASHRAE Standard 62.2-2010
|   | Make-up air | Make-up air will be provided for kitchen range fans exhausting more than 200 cubic feet per minute (CFM)  
54 |
|---|-------------|--------------------------------------------------------------------------------------------------|
| 6 | Combustion safety | Pressure effects will be assessed and corrected on drafting (of) for all natural draft combustion appliances as necessary  
55 |
|   | Occupant education | Occupant will be instructed to keep grease filters and termination fitting clean  
56 | Effectively move air from kitchen range to outside |

54 ANSI/ASHRAE Standard 62.2-2010  
56 ANSI/ASHRAE Standard 62.2-2010
## Topic: Exhaust
### Subtopic: Special Considerations

### 12) Detail Name: Regional Considerations

<table>
<thead>
<tr>
<th>Row</th>
<th>Region</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Very Cold    | Ventilation terminations will either have no back flow dampers or will use back flow dampers that resist freezing  
Soffit vents that contain a ventilation exhaust termination will be sealed within 6’ of the termination | Avoid ventilation flapper freezing  
Prevent exhaust moisture from entering the attic                                                                                          |
| 2   | Cold         | Exhaust ventilation will terminate at the roof, gable end or wall                                                                                                                                 | Prevent exhaust moisture from entering the attic                                                                 |
| 3   | Mixed Humid  | Ventilation ducts will be insulated to R-4 or greater  
Ventilation exhaust ducts will terminate on the exterior of the house  
Ventilation exhausts terminating through the soffit will direct exhaust air away from the soffit vents | Ensure condensation does not form on or in the ductwork  
Ensure ventilation exhaust exits the house to the outside  
Prevent exhaust moisture from entering the attic                                                                 |
| 4   | Hot Humid    | Exhaust only ventilation will not be installed                                                                                                                                 | Avoid bringing moist outside air into the house                                                                 |
| 5   | Marine       |                                                                                                                                                                                                               |                                                                                                                                                       |
| 6   | Hot Dry      |                                                                                                                                                                                                               |                                                                                                                                                       |
Supply

Components:
13) Supply Register Location
14) Intakes
15) Ducts for Supply
16) Intake to Forced Air System

Fans:
17) Inline or Multi-Port

Special Considerations:
18) Regional Considerations
**Topic: Supply**

**Subtopic: Components**

13) **Detail Name:** Supply Register Location

**Desired Outcome:**
- Supply register location optimizes air flow for either primary or spot ventilation devices

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Primary whole house</td>
<td>Supply register will be installed in high-occupancy rooms or rooms used for sleeping</td>
<td>Provide whole-house air exchange</td>
</tr>
<tr>
<td>2</td>
<td>Spot make up</td>
<td>Supply register will be installed in the room containing an exhaust device which exceeds 200 cubic feet per minute (CFM) of air flow</td>
<td>Provide make-up air</td>
</tr>
</tbody>
</table>
**Topic: Supply**  
**Subtopic: Components**

14) **Detail Name:** Intakes

**Desired Outcome:**
- Intake optimizes air flow while limiting the entry of insects, debris and contaminants

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hole in building shell</td>
<td>A hole as small as possible will be cut to accommodate intake fitting</td>
<td>Ensure a weathertight installation</td>
</tr>
<tr>
<td>2</td>
<td>Intake fitting</td>
<td>Intake fitting will have integrated collar at least the same diameter as the duct</td>
<td>Effectively draw the required volume of air from outside</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The fitting will be appropriate for regional weather conditions and installation location on exterior of house</td>
<td>Preserve integrity of the building envelope</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ensure durable installation</td>
</tr>
<tr>
<td>3</td>
<td>Occupant education</td>
<td>Intake fitting will be labeled “ventilation air intake”</td>
<td>Ensure unrestricted air flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Occupant will be instructed to keep yard debris and other contaminants clear of the intake (^{57})</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Damper (if applicable)</td>
<td>The damper will be installed to open in the direction of the desired flow</td>
<td>Preserve integrity of the building envelope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Damper will close when system is off</td>
<td>Ensure a weathertight and durable intake installation</td>
</tr>
<tr>
<td>5</td>
<td>Connection to intake fitting</td>
<td>Duct to intake fitting will be connected and sealed according to supply duct detail</td>
<td></td>
</tr>
</tbody>
</table>

\(^{57}\) ANSI/ASHRAE Standard 62.2-2010
<table>
<thead>
<tr>
<th>6</th>
<th>Weatherproofing</th>
<th>Ensure fasteners do not inhibit intake damper operation</th>
<th>Ensure unrestricted airflow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exterior termination fitting will be flashed or weather sealed</td>
<td>Water will be directed away from penetration</td>
<td>Manufacturer specifications will be followed</td>
</tr>
<tr>
<td></td>
<td>Installation will not inhibit damper operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Pest exclusion</td>
<td>Screen material no less than ⅛” and no greater than ½” hole size in any direction will be used 58</td>
<td>Prevent pest entry</td>
</tr>
<tr>
<td></td>
<td>Screen will be installed so it does not inhibit intake damper operation 59</td>
<td>Ensure unrestricted airflow</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Intake location</td>
<td>Intake will be installed according to the following:</td>
<td>Prevent contaminants from entering house</td>
</tr>
<tr>
<td></td>
<td>• 6” from grade</td>
<td></td>
<td>Ensure unrestricted airflow</td>
</tr>
<tr>
<td></td>
<td>• 10’ from contaminant sources or exhaust outlets</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Above local snow or flood line</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Never on an asphalt based or flat roof</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

58 ANSI/ASHRAE Standard 62.2-2010  
59 ANSI/ASHRAE Standard 62.2-2010
## Topic: Supply

**Subtopic:** Components

### 15) Detail Name: Ducts for Supply

**Desired Outcome:**
- Supply ducts effectively move the required amount of air and prevent condensation

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Duct design and configuration 60</td>
<td>Ducts will be as short, straight and smooth as possible</td>
<td>Effectively move the required volume of air</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ducts will not be smaller than the connections to which they are attached</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Duct insulation</td>
<td>Ducts will be insulated to a minimum of R-8 or equivalent to local codes</td>
<td>Prevent moisture condensation</td>
</tr>
<tr>
<td>3</td>
<td>Duct support 61</td>
<td>Ducts will be supported at intervals of no more than 4’ of horizontal run</td>
<td>Effectively move the required volume of air</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supports with a minimum width of 1 ½” will be used</td>
<td>Preserve the integrity of the duct system</td>
</tr>
<tr>
<td>4</td>
<td>Duct connections 62</td>
<td>Metal-to-metal or metal-to-PVC will be fastened with a minimum of three equally spaced screws</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flexible duct-to-metal or flexible duct-to-PVC will be fastened with tie bands using a tie band tensioning tool</td>
<td>Effectively move the required volume of air</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Preserve integrity of the duct system and building envelope</td>
</tr>
</tbody>
</table>

---

60 SMACNA HVAC Duct Construction Standard  
61 SMACNA HVAC Duct Construction Standard  
62 SMACNA HVAC Duct Construction Standard
Flexible duct between the cable tie and end of metal or PVC duct will be screwed

PVC-to-PVC materials will be fastened with approved PVC cement

Other specialized duct fittings will be fastened according to manufacturer specifications

Supply ducts attached to the return side of forced air systems will be:

- Attached as close to the heating, ventilation and air conditioning (HVAC) systems fan as possible while remaining in compliance with manufacturer specifications
- Set up to provide filtration of ventilation air before reaching the HVAC system
- Attached via a mechanically fastened takeoff collar

In addition to mechanical fasteners, air seal duct connections will be fastened with UL 181B or 181B-M listed material
|   | Duct materials $^{63}$ | Flexible duct materials will be UL 181 listed or Air Diffusion Council approved | Effectively move the required volume of air  
Preserve integrity of the duct system and building envelope |
|---|-------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
|   | **Intake Location** | Install intakes:  
- 6’ minimum above grade  
- 10’ minimum from exhaust outlets, plumbing vent outlets, or combustion vent outlets  
- Above local snow or flood line  
- Minimum 18” above an asphalt-based or flat roof | Reduce opportunity for contaminants to enter the house through the ventilation system |
### Topic: Supply
**Subtopic:** Components

16) Detail Name: Intake to Forced Air System

**Desired Outcome:**
- Intake reduces pollutant entry, is easily maintained, has proper flow and enhances house durability

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Forced air system requirements</td>
<td>Forced air system leakage will be less than 10% of the air handler flow when measured at 25 Pascals</td>
<td>Reduce migration of pollutants from unconditioned spaces</td>
</tr>
<tr>
<td>2</td>
<td>Wiring</td>
<td>Wiring will be installed by a licensed electrician in accordance with local codes and manufacturer specifications</td>
<td>Prevent an electrical hazard</td>
</tr>
<tr>
<td>3</td>
<td>Access</td>
<td>Motorized damper and service switch will be accessible for maintenance</td>
<td>Ensure accessibility for maintenance</td>
</tr>
<tr>
<td>4</td>
<td>Mounting intake duct</td>
<td>Ventilation duct will be attached as close to the heating, ventilation and air conditioning (HVAC) systems fan as possible while remaining in compliance with manufacturer specifications Filtration of ventilation air will be provided before reaching the HVAC system Duct will be connected to intake fitting Connection and seal will be performed according to supply duct detail</td>
<td>Ensure short duct run to achieve optimum air flow Preserve integrity of the duct system and building envelope</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Motorized damper</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>A motorized damper will be installed between the intake fitting and the return side of the air handler. Damper control will be linked to scheduled operation.</td>
<td>Prevent air flow when none is desired.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Intake filter</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6</strong></td>
<td>An accessible filter will be installed. The filter will be able to remove contaminants consistent with at least minimum efficiency reporting value (MERV) 11 or equivalent. Filter systems that produce ozone will not be allowed.</td>
<td>Protect occupant health and safety. Preserve integrity of the building envelope.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Occupant education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>7</strong></td>
<td>Occupant will be educated on how and when to change filter.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

64 ANSI/ASHRAE Standard 62.2-2010
### Topic: Supply
#### Subtopic: Fans

**17) Detail Name:** Inline or Multi-Port

**Desired Outcome:**
- Inline or multi-port fan installed according to specifications

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wiring</td>
<td>Wiring will be installed by a licensed electrician in accordance with local codes and manufacturer specifications</td>
<td>Prevent an electrical hazard</td>
</tr>
<tr>
<td>2</td>
<td>Access</td>
<td>Fan and service switch will be accessible for maintenance</td>
<td>Achieve designed air flow</td>
</tr>
</tbody>
</table>
| 3   | Fan mounting                     | Fan will be oriented with inlet toward the fan intake fitting

  - Fan will be securely mounted according to manufacturer specifications

  - Fan will be isolated from the building framing unless specifically designed to be directly attached

  - Fan will be installed remotely by ducting from supply register or grilles

  Ensure short duct run to achieve optimum air flow

  Ensure fan is mounted securely

  Ensure fan housing or building framing does not shake, rattle or hum when operating

  Minimize noise

| 4   | Damper (required for intermittent operation) | The damper will be installed to open in the direction of the desired flow

  - Damper will close when system is off

  Ensure unrestricted air flow
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| **5** | **Duct connections** | Ducts will be connected and sealed to the intake fitting, fan and register or grilles according to supply duct detail | Provide desired air flow  
Preserve integrity of the duct system and building envelope |
| **6** | **Filter** | An accessible filter will be installed between the intake fitting and the fan  
Contaminant removal will be consistent with at least minimum efficiency reporting value (MERV) 11 or equivalent  
Filter systems that produce ozone will not be allowed | Protect occupant health and safety  
Preserve integrity of the building envelope |
| **7** | **Occupant education** | Occupant will be educated on how and when to change filter 65 | Protect occupant health and safety |
| **8** | **Boot to interior surface seal** 66 | Sealants will be compatible with their intended surfaces  
Sealants will be continuous and meet fire barrier specifications | Prevent air leakage around intake housing  
Ensure a permanent seal to the building air barrier  
Prevent a fire hazard |

65 ANSI/ASHRAE Standard 62.2-2010  
66 ASTM C1193 - 09
**Topic:** Supply  
**Subtopic:** Special Considerations

18) **Detail Name:** Regional Differences

<table>
<thead>
<tr>
<th>Row</th>
<th>Region</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Very Cold    | Ventilation intakes will be installed at a low point or have a continuous operating fan  
Ventilation intake will be located above snow line  
Supply ventilation will be independent of the forced air system | Ensure proper ventilation rates  
Avoid increased moisture entering the house  
Ensure energy use and comfort are not compromised by over ventilating |
| 2   | Cold         | Ventilation intake must be located above snow line                                | Ensure proper ventilation rates and avoid increased moisture entering the house |
| 3   | Mixed Humid  |                                                                                  |                                                                               |
| 4   | Hot Humid    | Intake will not terminate on roof  
When the primary ventilation fan is the air handler, the controller will be used only to control the ventilation damper, not to start the air handler fan  
Intake for supply will be attached to the system as close to the intake of the coils as possible | Avoid excessive heat from entering ventilation air  
Ensure energy use and comfort are not compromised  
Ensure proper pressure in intake duct |
| 5   | Marine       |                                                                                  |                                                                               |
| 6   | Hot Dry      |                                                                                  |                                                                               |
Whole House Ventilation

Air Flow Requirements:

19) Installed System Air Flow
20) Primary Ventilation Air Flow Between Rooms

Other Components:

21) Controls
22) Heat Recovery Ventilation (HRV) and Energy Recovery Ventilator (ERV) Installation

Dehumidifiers:

23) Stand Alone
24) Ventilator

Special Considerations:

25) Regional Considerations
26) Hot and Humid Climate Impact
27) Sound Rating Limits
**Topic: Whole House Ventilation**

**Subtopic: Air Flow Requirements**

19) **Detail Name:** Installed System Air Flow

**Desired Outcome:**
- Installed system air flow meets required standards

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Separate exhaust for all baths and kitchens plus primary ventilation | Air flows will meet the following requirements:  
  Bath:  
  - 20 cubic feet per minute (CFM) continuous  
  **OR**  
  - 50 CFM intermittent  
  Kitchen:  
  - Minimum 100 CFM intermittent  
  Primary ventilation:  
  - Air flow rate will be no less than 7.5 CFM per person + 1 CFM per 100 square feet floor area of conditioned space= continuous use  
  (Minimum number of people = number of bedrooms plus one)  
  For intermittent use, ASHRAE 62.2-2010, or Appendix A-Existing Buildings will be used | Provide sufficient flows per current ventilation standard |

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67 ANSI/ASHRAE Standard 62.2-2010  
68 ANSI/ASHRAE Standard 62.2-2010  
69 ANSI/ASHRAE Standard 62.2-2010
<table>
<thead>
<tr>
<th>2</th>
<th>Separate exhaust for all baths and kitchens sufficient to meet primary ventilation requirements</th>
</tr>
</thead>
</table>

Air flows will meet the following requirements:

**Bath:**
- 20 CFM continuous
- OR
- 50 CFM intermittent

**Kitchen:**
- Minimum 100 CFM intermittent
- Air flow through bath or kitchen fan rated at 1 sone or less will be no less than 7.5 CFM per person + 1 CFM per 100 square feet = continuous use

(Minimum number of people = number of bedrooms plus one)

For intermittent use, ASHRAE 62.2-2010 or Appendix A-Existing Buildings will be used

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70 ANSI/ASHRAE Standard 62.2-2010
71 ANSI/ASHRAE Standard 62.2-2010
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 3 | **Single additional fan to meet all ventilation requirements** | Air flows will meet the following requirements:  
For continuous use: \(^72\)  
- 7.5 CFM per person + 1 CFM per 100 square feet, with adjustments  
- Refer to Appendix C for additional assistance in meeting ventilation flows  
(Minimum number of people = number of bedrooms plus one)  
For intermittent use, ASHRAE 62.2-2010 or Appendix C will be used  
Provide sufficient flows per current ventilation standard |
| 4 | **Reducing fan air flow requirement based on blower door or building leakage measurement (optional)** | Required fan air flow may be reduced by using ASHRAE 62.2-2010 infiltration credit (section 4.1.3) and alternative compliance for existing buildings (Appendix A) |

\(^72\) ANSI/ASHRAE Standard 62.2-2010
Topic: Air Flows  
Subtopic: Air Flow Requirements

20) **Detail Name:** Primary Ventilation Air Flow Between Rooms

**Desired Outcome:**
- Air circulates freely between rooms

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Balancing pressure</td>
<td>An appropriate means of pressure balancing will be installed (e.g., transfer</td>
<td>Ensure free flow of air between rooms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>grilles, jumper ducts, individual room returns)</td>
<td>Preserve integrity of the building envelope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No room will exceed +/- 3 Pascals with reference to the outside with all</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>interior doors closed and ventilation systems running</td>
<td></td>
</tr>
</tbody>
</table>
**Topic: Whole House Ventilation**

**Subtopic: Other Components**

21) **Detail Name:** Controls

**Desired Outcome:**
- Fan controls support ventilation strategy

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Primary ventilation fan (whole house volume) | Controls will be used that can meet the following conditions:  
  - Run fan continuously  
  - Run fan intermittently with the intended schedule of operation for intermittent operation  
  - Operate fan to produce the intended flow for each intended flow setting  
  - A labeled switch will be included for the ventilation system | Deliver intended air exchange  
Ensure fan controls meet intended ventilation strategy                                                                                                 |
| 2   | Spot fan                                   | Controls will be used that meet the following conditions:  
  - Run fan intermittently with the intended schedule of operation for intermittent operation  
  - Run fan for intended time for timed operation  
  - Operate fan to produce the intended flow for                                                                                                           |
<table>
<thead>
<tr>
<th></th>
<th>each intended flow setting</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wiring</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Wiring will be installed by a licensed electrician in accordance with local codes and manufacturer specifications</td>
<td>Prevent an electrical hazard Ensure controls fan meets intended ventilation strategy</td>
</tr>
<tr>
<td></td>
<td>A system operation guide designed for occupants (non-professionals) will be provided to explain how and why to operate system</td>
<td>Educate occupants about system operation and importance Deliver intended air exchange</td>
</tr>
<tr>
<td>4</td>
<td>Occupant education</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A label indicating the presence and purpose of the ventilation system will be included or a copy of the system operation guide will be posted at the electrical panel</td>
<td></td>
</tr>
</tbody>
</table>
**Topic: Whole House Ventilation**

**Subtopic: Other Components**

22) **Detail Name:** Heat Recovery Ventilation (HRV) and Energy Recovery Ventilator (ERV) Installation

**Desired Outcome:**
- HRV and ERV systems installed to specifications

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wiring</td>
<td>Wiring will be installed by a licensed electrician in accordance with local codes and manufacturer specifications</td>
<td>Prevent an electrical hazard</td>
</tr>
<tr>
<td>2</td>
<td>Access</td>
<td>Fans, service switch, filters, drain and drain pan will be accessible for maintenance</td>
<td>Maintain designed air flows and system performance</td>
</tr>
<tr>
<td>3</td>
<td>Fan mounting</td>
<td>Fan will be securely mounted according to manufacturer specifications</td>
<td>Ensure short duct runs to achieve optimum air flows</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A drain pan will be installed on the bottom</td>
<td>Ensure the fan is mounted securely</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fan will be oriented to ensure shortest, most direct duct runs to exterior fittings</td>
<td>Ensure fan housing or building framing does not shake, rattle or hum when operating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fan will be isolated from the building framing unless specifically designed to be directly attached</td>
<td>Minimize noise</td>
</tr>
<tr>
<td>4</td>
<td>Backdraft dampers (required for intermittent operation)</td>
<td>A backdraft damper will be installed between the Heat Recovery Ventilator (HRV) or Energy Recovery Ventilator (ERV) and the exterior, unless the system operates</td>
<td>Prevent reverse air flow when the system is off</td>
</tr>
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<td>---</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>continuously</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><strong>Installation of fittings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The intake fitting will be installed as described in the intake fitting detail</td>
<td>Achieve the desired air flows to and from the designated locations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The termination fitting will be installed as described in the termination fitting detail</td>
<td>Ensure unrestricted air flow</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Preserve integrity of the building envelope</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td><strong>Duct connections</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ducts will be connected to applicable registers or grilles, collector box, HRV or ERV, intake fitting and termination fitting</td>
<td>Achieve the desired air flows to and from the desired locations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ducts will be connected and sealed according to duct exhaust and supply duct detail</td>
<td>Preserve integrity of the duct system and building envelope</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><strong>Duct layout</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exhaust air will not be taken from the forced air system</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supply ducts attached to the return side of forced air systems will be:</td>
<td>Achieve the desired air flows to and from the desired locations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Attached as close to the HVAC systems fan as possible while remaining in compliance with manufacturer specifications</td>
<td>Preserve integrity of duct system and house</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Set up to provide filtration of ventilation air before reaching the heating, ventilation and air conditioning (HVAC) system</td>
<td>Protect occupant health and safety</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Insulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>•</strong> Connected to the intake fitting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>•</strong> Connected and sealed according to the supply duct detail</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Ducts outside of the thermal envelope will be insulated**
Supply ducts will be insulated between the HRV or ERV and the outside air intake to a minimum of R-8 or equivalent to local codes

**Preserve integrity of the duct system by eliminating condensation**

<table>
<thead>
<tr>
<th>9</th>
<th>Sealant selection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gap between registers or grilles and interior surface will be sealed</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sealants will be compatible with their intended surfaces</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sealants will be continuous and meet fire barrier specifications</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Prevent air leakage around registers or grilles**
**Ensure a permanent seal**
**Prevent a fire hazard**

<table>
<thead>
<tr>
<th>10</th>
<th>Balance and flow</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air flows will match to the system’s intent</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Achieve the desired air flows to and from the desired locations**

<table>
<thead>
<tr>
<th>11</th>
<th>Occupant education</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Occupant will be educated on how and when to change filter and clean drain pan according to manufacturer specifications</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Protect occupant health**
**Preserve integrity of system**
### Topic: Whole House Ventilation

#### Subtopic: Dehumidifiers

**23) Detail Name:** Dehumidifiers: Stand Alone

**Desired Outcome:**
- Humidity controlled to achieve optimum indoor air quality (IAQ)

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Equipment | Equipment will be ENERGY STAR® rated  
Settings will be maintained through power failure (auto restart)  
System will be connected directly to condensate line that drains to a plumbing drain or the exterior, away from the home’s foundation(hose not connected to bucket)  
Systems located in a basement or crawl space will be rated for cold temperature operation | Efficiently remove humidity  
Ease of operation  
Reliably dispose of condensate |
| 2   | Sizing   | System will be selected with enough capacity to handle humidity from outside air ventilation and internal gains  
Humidity levels will be maintained less than 60% | Efficiently remove humidity |
| 3   | Location | Dehumidifiers will be located in or near the return air pathway with access to electrical outlet and place to dispose of the condensate | Easily maintain equipment  
Distribute dehumidified air |
|   | Condensate | Condensate line will be directly attached to threaded connection of system to drain outside | Dispose of water quickly |
**Topic: Whole House Ventilation**  
**Subtopic: Dehumidifiers**

**24) Detail Name:** Dehumidifiers: Ventilator

**Desired Outcome:**
- Humidity controlled to achieve optimum indoor air quality (IAQ)

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equipment</td>
<td>Equipment will be ENERGY STAR® rated</td>
<td>Efficiently remove humidity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Settings will be maintained through power failure (auto restart)</td>
<td>Operate equipment easily</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dehumidification ventilator will be a ducted unit</td>
<td>Provide ventilation with outside air</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dehumidification ventilator will be able to provide outside air</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Sizing</td>
<td>System with enough capacity to handle humidity from outside air ventilation and internal gains will be selected</td>
<td>Efficiently remove humidity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Humidity levels will be maintained less than 60%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Location</td>
<td>Equipment will be located in an area with access to HVAC supply trunk line or plenum, outside air</td>
<td>Easily maintain equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Access for maintenance, electrical service and removal of condensate will be provided</td>
<td>Distribute outside air</td>
</tr>
<tr>
<td>4</td>
<td>Outside air</td>
<td>In a hot and humid climate, outside air will be provided at the rate specified by ASHRAE 62.2 and must be pre</td>
<td>Improve indoor air quality</td>
</tr>
<tr>
<td></td>
<td>ventilation rate</td>
<td></td>
<td>Increase energy efficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>conditioned</td>
<td>Avoid moisture problems associated with over-ventilation in a hot and humid climate 73</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>5</td>
<td>Installation</td>
<td>Installation will be according to manufacturer specifications and local codes</td>
<td>Maintain manufacturer warranty and proper installation</td>
</tr>
<tr>
<td>6</td>
<td>Controls</td>
<td>Humidity control and sensor will be installed near thermostat</td>
<td>Humidity in the house controls the system operation</td>
</tr>
</tbody>
</table>

73 ANSI/ASHRAE Standard 62.2-2010
**Topic: Whole House Ventilation**  
**Subtopic: Special Considerations**

**25) Detail Name:** Regional Considerations

<table>
<thead>
<tr>
<th>Row</th>
<th>Region</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very Cold</td>
<td>Energy recovery ventilators will not be installed</td>
<td>Prevent freezing of ventilator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A filter box will be installed before Heat Recovery Ventilator (HRV)</td>
<td>Ensure the ventilation system remains clean and operates properly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ventilation ducts will be insulated to R-19</td>
<td>Ensure condensation does not form on or in the ductwork</td>
</tr>
<tr>
<td>2</td>
<td>Cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Mixed Humid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Hot Humid</td>
<td>HRVs will not be installed</td>
<td>Avoid low energy recovery equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ventilation air intake will not be terminated at roof</td>
<td>Prevent excessive heat from entering ventilation air</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Determine whether net latent load from ventilation (both natural and mechanical) requires dehumidification. If so, install dehumidification (see details 24 and 25)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
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<td>----------</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hot Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Topic: Whole House Ventilation**

**Subtopic: Special Considerations**

26) **Detail Name:** Sound Rating Limits

**Desired Outcome:**
- Systems operate as quietly as possible

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Primary ventilation system or any continuously operating fan</td>
<td>System will be no louder than 40 A-weighted decibels (dBA) when measured 5’ from any grille 74</td>
<td></td>
</tr>
</tbody>
</table>
| 2   | Intermittent spot ventilation system | Spot ventilation other than kitchen range fan will be no louder than 50 dBA when measured 5’ from any grille 75  
Kitchen range fan will be no louder than 60 dBA when measured 5’ from intake grille 76 | Minimize noise |

74 ANSI/ASHRAE Standard 62.2-2010  
75 ANSI/ASHRAE Standard 62.2-2010  
76 ANSI/ASHRAE Standard 62.2-2010
Appendix C

Adjustments to Primary Ventilation Fan Flow Rate, including Infiltration Credit and ASHRAE Standard 62.2-2010, Appendix A (calculation for alternative compliance for existing houses using a single fan)

Calculation of the Infiltration Credit:
The infiltration credit that can be used to reduce the required installed fan flow requires a series of calculations. These calculations can be reduced to a few inputs using certain assumptions. This section provides this reduced equation for infiltration and shows how to use this to determine the credit for infiltration. For a more detailed step-by-step discussion see the end of this appendix.

1) The infiltration rate at operating conditions, measured in CFM, can be estimated as

\[ I_{CFM} = 0.0508 \times w \times S \times Q_{50} \]

In this equation:
- \( S \) is a factor accounting for the height of the house, determined from Table A-1
- \( Q_{50} \) is the blower door test result in CFM50 (cubic feet per minute at 50 Pa)
- \( w \) is the weather factor from ASHRAE Standard 136

Table A-1. S factors for various house heights

<table>
<thead>
<tr>
<th>Number of stories</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S )</td>
<td>1</td>
<td>1.13</td>
<td>1.23</td>
<td>1.32</td>
<td>1.39</td>
</tr>
</tbody>
</table>

2) The default infiltration rate \( I_d \) from ASHRAE Standard 62.2, measured in CFM, is

\[ I_d = 0.02 \times A_{floor} \]

3) If \( I_{CFM} \) is greater than \( I_d \) then the infiltration credit \( I_{cred} \) can be calculated as

\[ I_{cred} = \frac{1}{2} (I_{CFM} - I_d) \]

Use of ASHRAE Standard 62.2-2010, Appendix A
ASHRAE Standard 62.2-2010, includes an appendix that details an alternative compliance method intended for existing homes that did not meet the ASHRAE 62.2 local exhaust requirements when built. The strategy is to evaluate how much local exhaust deficit there is in each room that should have local exhaust, based on intermittent fan requirements, and increase the continuous primary fan flow rate to account for this deficit. This section provides guidance on how to determine the increase to the primary fan flow rate to comply with ASHRAE 62.2-2010.
Per ASHRAE 62.2-2010

- each bathroom should have a 50 CFM fan if used intermittently
- each kitchen should have a 100 CFM fan if used intermittently

For each of these rooms that does not meet these requirements:

1. Calculate the deficit – if there is a fan that exhausts to outside but it does not have the required flow, the deficit is only the difference between the required flow and the measured flow.
2. Reduce the deficit by 20 CFM for each of these rooms that have an operable window.
3. Sum up all of the individual deficits
4. Divide by 4
5. Add the result to the required primary fan flow rate

Example #1:

- Kitchen has no exhaust to outside but an operable window
- Bathroom #1 has no exhaust but an operable window
- Bathroom #2 has a fan that moves only 32 CFM

Deficit for kitchen is 100-20 = 80 CFM (20 CFM credit for operable window)
Deficit for bathroom #1 is 50-20 = 30 CFM (20 CFM credit for operable window)
Deficit for bathroom #2 is 50-32 = 18 CFM

Sum of deficits is 80+30+18 CFM = 128 CFM
Increase required primary fan flow rate by 128/4 = 32 CFM

Example #2:

- Kitchen has a fan to outside that moves only 60 CFM and an operable window
- Bathroom #1 has a fan that moves only 20 CFM
- Bathroom #2 has a fan that moves only 32 CFM

Deficit for kitchen is 100-60-20 = 20 CFM (20 CFM credit for operable window)
Deficit for bathroom #1 is 50-20 = 30 CFM
Deficit for bathroom #2 is 50-32 = 18 CFM

Sum of deficits is 20+30+18 CFM = 68 CFM
Increase required primary fan flow rate by 68/4 = 17 CFM

**Detailed Step-by-Step Process for Determining Infiltration Credit**
The infiltration credit using only a blower door result, three house characteristics (floor area, volume, number of above-grade stories), and a factor used to account for local weather.

The calculations that are required are for the equivalent leakage area (ELA), normalized leakage (NL), and Infiltration (I) at normal operating conditions.

1) Calculation of ELA

\[
ELA = \frac{Q_{50}}{50^n} \Delta P^n \sqrt{\frac{\rho}{2 \Delta P}}
\]

Where

- \(Q_{50}\) = blower door leakage at 50 Pa (ft³/min @ 50 Pa (or CFM50))
- \(n\) = house leakage curve exponent
- \(\Delta P\) = reference pressure difference between inside and outside (Pa)
- \(\rho\) = density

By assuming that \(n = 0.65\) (experimental average value for residential houses), \(\Delta P = 4\) Pa (typical reference value for ELA), and the density is a constant of 1.2 kg/m³, the ELA can be rewritten as, and by converting all metric units to consistent inch-pound (I-P) units:

\[
ELA = 0.000381 \times Q_{50} \text{ (with } Q_{50} \text{ measured as CFM50, ELA has units of ft}^2\)
\]

2) Calculation of NL

\[
NL = \frac{1000 \times ELA}{A_{floor}} \left( \frac{H}{H_0} \right)^{0.3}
\]

Where

- \(A_{floor}\) = floor area of the house (ft²)
- \(H\) = height of the house above grade (ft)
- \(H_0\) = reference height of one story = 8 ft

The normalized leakage was developed assuming that the volume is 8 feet multiplied by the floor area. Using this assumption, substituting for \(ELA\), and by assuming that the height of one story above grade is 8 ft, the \(NL\) can be rewritten as:

\[
NL = \frac{3.048 \times Q_{50}}{V} \left( \frac{\text{stories}}{V} \right)^{0.3}
\]

where \(V\) = volume of the house (ft³)

3) Calculation of Infiltration at normal operating conditions
\[ I = NL \cdot w \]

Where \( w \) = a weather factor specific to a geographic location

In this equation \( I \) is in air changes per hour (ACH). The weather factor can be found in a table in ASHRAE Standard 136.

Once the infiltration \( I \) is determined, it can be converted to cubic feet per minute (CFM) using the volume of the house.

\[ I_{CFM} = \frac{I \cdot V}{60} \]

Where \( I_{CFM} \) = infiltration in cubic feet per minute
\( 60 \) = conversion from hours to minutes

The infiltration rate at operating conditions, measured in CFM, can then be estimated as

\[ I_{CFM} = 0.0508 \cdot w \cdot (\text{stories})^{0.3} \cdot Q_{50} \]

4) Calculation of ASHRAE Standard 62.2 default infiltration rate

The default infiltration rate \( I_d \) from ASHRAE Standard 62.2, measured in CFM, is

\[ I_d = 0.02 \cdot A_{\text{floor}} \]

5) Determination of infiltration credit, to be credited against required primary ventilation fan flow

If \( I_{CFM} \) is greater than \( I_d \), then the infiltration credit \( I_{cred} \) can be calculated as

\[ I_{cred} = \frac{1}{2} (I_{CFM} - I_d) \]
SECTION 4: AIR SEALING

Table of Contents

Health and Safety

Safe Work Practices: ¹
1) Air Sealing Worker Safety
2) Air Sealing Moisture Precautions
3) Radon

Attic Sealing

Penetrations and Chases:
4) Penetrations
5) Chase Sealing
6) Chase Capping
7) Pocket Door

Open Stairwells:
8) Interior with Sloped Ceiling
9) Stairwell to Attic - Door at Bottom with No Ceiling Above
10) Stairwell to Attic - Door at Top with Finished Ceiling Above

Dropped Ceilings and Soffits:
11) Raised Top-Plate with Walls Open to Attic
12) New Ceiling Below Original - Old Ceiling Intact or Repairable
13) Above Closets and Tubs
14) Ceiling Leaks Not Repairable – No Air Barrier Above
15) 3-D Walls
16) Dropped Ceiling with Light Boxes and Fixtures
17) Dropped Soffits

Other Ceiling Types:
18) Tongue and Groove Ceilings
19) Cathedralized Attic Ceilings

Considerations:

¹ Appendix D – OSHA Personal Protective Equipment Standards
20) Regional Considerations

**Garage Sealing**

Garage Openings:
21) Penetrations, Cracks and Doors between Garage and House

**Window and Door Sealing**

Maintenance and Repair:
22) Double-Hung Wood Windows
23) Single-Unit Window and Fixed Frame with Wood Sash
24) Exterior Doors

Cracked and Broken Glass:
25) Fixed Frame with Wood Sash — Older House
26) Single-Unit Window, Mounted on Rough Opening — Newer House

Replacement:
27) Fixed Frame with Wood Sash — Older House
28) Single-Unit Window, Mounted on Rough Opening — Newer House
Health and Safety

Safe Work Practices:

1) Air Sealing Worker Safety
2) Air Sealing Moisture Precautions
3) Radon
### Topic: Health and Safety

#### Subtopic: Safe Work Practices

1) **Detail Name:** Air Sealing Worker Safety

**Desired Outcome:**
- Work completed safely without injury or hazardous exposure

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objectives(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hand protection</td>
<td>Durable and wrist protecting gloves will be worn that can withstand work activity[^2]</td>
<td>Minimize skin contact with contaminants</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Protect hands from sharp objects</td>
</tr>
<tr>
<td>2</td>
<td>Respiratory protection</td>
<td>Respirators appropriate for the contaminants present will be worn (e.g. N-95 or equivalent face mask)[^3]</td>
<td>Minimize exposure to airborne contaminants (e.g. insulation materials, mold spores, feces, bacteria, chemicals)</td>
</tr>
<tr>
<td>3</td>
<td>Electrical safety[^4,5]</td>
<td>An electrical safety assessment will be performed[4,5][6] All electric tools will be protected by Ground-Fault Circuit Interrupters[^6][6] Extension cords used with portable electric tools will be of three-wire type[6] Worn or frayed electric cords will not be used[6] Metal ladders will be avoided[6] Water, such as condensate pans, and electrical sources will be kept separate[6] Special precautions will be taken[6]</td>
<td>Avoid electrical shock and arc flash hazards</td>
</tr>
</tbody>
</table>

[^2]: OSHA Technical Manual Section VIII: Chapter 1, part III
[^3]: OSHA Technical Manual Section VIII: Chapter 2, section IV
[^5]: 29 CFR 1926 Subpart K – Electrical
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 4 | Protective clothing | taken if knob and tube wiring is present  
Aluminum foil products will be kept away from live wires |
|   |   | If contaminants are present,  
(e.g. insulation materials)  
removable protective clothing will be worn  
Eye protection will always be worn  
(e.g. safety glasses, goggles if not using full face respirator) |
|   |   | Protect worker from skin contact with contaminants  
Minimize spread of contaminants |
| 5 | Confined space safety | Access and egress points will be located before beginning work  
Inspection will be conducted for frayed electrical wires  
Adequate ventilation will be provided  
Use of toxic material will be reduced |
|   |   | Prevent build-up of toxic or flammable contaminants  
Provide adequate access and egress  
Avoid electrical shock |
| 6 | Power tool safety | Power tools will be inspected and used according to manufacturer specifications to eliminate hazards associated with missing ground prongs, ungrounded circuits, misuse of power tools, noise, and improper or defective cords or extension cords  
All devices used will be verified as GFI protected or |
|   |   | Prevent power tool injuries |

7 OSHA Technical Manual Section VIII: Chapter 1, part III  
8 ASTM D4276 - 02(2007)  
10 29 CFR 1910 Subpart P - Hand and portable powered tools and other hand-held equipment
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>double insulated 11</td>
<td>Exhaust gases from compressors and generators will be prevented from entering crawl space</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Chemical safety</td>
<td>The least toxic suitable material will be chosen</td>
<td>Prevent worker exposure to toxic substances</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chemicals will be handled according to manufacturer instructions or Material Safety Data Sheets standards to eliminate hazards associated with volatile organic compounds (VOCs), sealants, insulation, contaminated drywall, dust, foams, asbestos, lead and fibers 12</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Ergonomic safety 13</td>
<td>Personal Protective Equipment will be used (e.g. knee pads, bump caps, additional padding) Proper equipment will be used for work Proper lifting techniques will be used</td>
<td>Avoid injuries from awkward postures, repetitive motions and improper lifting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Hand tool safety</td>
<td>Hand tools will be used for intended purpose 14</td>
<td>Reduce injuries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Slips, trips and falls 15</td>
<td>Caution will be used around power cords, hoses, tarps and plastic sheeting Precautions will be taken when ladders are used, when</td>
<td>Eliminate injuries due to slips, trips and falls</td>
</tr>
</tbody>
</table>


12 29 CFR 1910 Subpart Z - Toxic and Hazardous Substances


14 29 CFR 1910 Subpart P - Hand and portable powered tools and other hand-held equipment

15 29 CFR 1926 Subpart M - Fall Protection
| 11 | **Heat and thermal stress**<sup>16</sup> | working at heights or when balancing on joists  
Walk boards will be used when practical  
Appropriate footwear and clothing will be worn  
Appropriate ventilation, hydration, rest breaks and cooling equipment will be used  
Dial 911 when necessary | Reduce heat stroke, heat stress and cold stress related injuries |
|---|---|---|---|
| 12 | **Fire safety** | Ignition sources will be identified and eliminated (e.g. turn off pilot lights and fuel supply)  
Flammable material will be reduced and fire-rated materials will be used<sup>17</sup> | Prevent a fire hazard |

---

<sup>16</sup> 29 CFR 1926 Subpart C - General Safety and Health Provisions  
<sup>17</sup> Appendix D – OSHA Personal Protective Equipment Standards
**Topic: Health and Safety**  
**Subtopic: Safe Work Practices**

2) **Detail Name:** Air Sealing Moisture Precautions

- **Desired Outcome:** Ensure durability of repairs and reduce potential for occupant exposure to mold and other moisture related hazards

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objectives(s)</th>
</tr>
</thead>
</table>
| 1   | Moisture precautions for attics | Roof leaks will be repaired before performing attic air sealing or insulation  
Moisture sources in the house that can generate moisture into the attic will be identified and removed or reduced | Ensure durability of repairs  
Reduce potential for occupant exposure to mold and other moisture related hazards |
| 2   | Moisture precautions for crawl spaces and basements | Exposed earth will be covered with a continuous, durable, sealed vapor retarder  
Un-designed penetrations between the crawl space or basement and outside will be sealed  
Holes between the crawl space or basement and the living space will be sealed | Ensure durability of repairs  
Reduce potential for occupant exposure to mold and other moisture related hazards |
| 3   | Moisture precautions for the living space | Moisture sources in the home will be identified and removed or reduced  
Local ventilation will be installed where appropriate (e.g., baths, kitchens) and vented to outside according to ASHRAE 62.2  
Unvented combustion appliances will be removed | Ensure durability of repairs  
Reduce potential for occupant exposure to mold and other moisture related hazards |
| 4 | **Moisture precautions for exterior water** | Before insulating basement or crawl space walls near wet areas, surface water pooling near the foundation will be addressed by:

- Repairing, modifying or replacing gutters and downspouts
- Grading and subsurface drainage at critical locations (e.g., localized drain and grading beneath valleys) according to EPA Indoor airPLUS Construction Specifications Section 1.1 | Minimize occupant exposure to moisture and mold |

If replacing air conditioning system, new system will be sized to optimize dehumidification

Where appropriate, a properly sized dehumidifier will be installed
**Topic: Health and Safety**

**Subtopic: Safe Work Practices**

3) **Detail Name:** Radon

**Desired Outcome:**
- Work completed without increasing occupant exposure to radon

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objectives(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Radon testing and mitigation</td>
<td>EPA guidelines for radon in current edition of “Healthy Indoor Environment Protocols for Home Energy Retrofits” will be followed</td>
<td>Complete retrofit work without increasing occupant exposure to radon</td>
</tr>
</tbody>
</table>
**Attic Sealing**

**Penetrations and Chases:**
1. Penetrations
2. Chase Sealing
3. Chase Capping
4. Pocket Door

**Open Stairwells:**
5. Interior with Sloped Ceiling
6. Stairwell to Attic - Door at Bottom with No Ceiling Above
7. Stairwell to Attic - Door at Top with Finished Ceiling Above

**Dropped Ceilings and Soffits:**
8. Walls Open to Attic – Balloon Framing and Double Walls
9. New Ceiling Below Original - Old Ceiling Intact or Repairable
10. Above Closets and Tubs
11. Ceiling Leaks Not Repairable – No Air Barrier Above
12. 3-D Walls
13. Dropped Ceiling with Light Boxes and Fixtures
14. Dropped Soffits

**Other Ceiling Types:**
15. Tongue and Groove Ceilings
16. Cathedralized Attic Ceilings

**Special Considerations:**
17. Regional Considerations
Topic: Attic Sealing
Subtopic: Attic Penetrations and Chases

4) **Detail Name:** Penetrations and Chases

**Desired Outcome:**
- Penetrations and chases sealed to prevent air leakage and moisture movement between the attic and conditioned space \(^{19}\)

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Pre-inspection               | An inspection will be conducted for mold, water leaks and water damage before sealing a chase  
Repairs will be completed before work                                                 | Repair moisture-related issues                                                                        |
| 2   | Backing and infill           | Backing or infill will be provided as needed to meet the specific characteristics of the selected material and the characteristics of the hole  
The infill or backing will not bend, sag or move once installed | Minimize hole size to ensure successful use of sealant  
Ensure closure is permanent and supports any load (e.g., wind and insulation)  
Ensure sealant does not fall out                                                       |
| 3   | Sealant selection            | Sealants will be compatible with their intended surfaces  
Sealants will be continuous and meet fire barrier specifications \(^{20}\) | Select permanent sealant  
Ensure sealant meets or exceeds the performance characteristics of the surrounding materials |
| 4   | High temperature application | Only non-combustible materials will be used in contact with chimneys, vents and flues \(^{21}\) | Prevent a fire hazard                                                                              |

\(^{19}\) ASTM E1186 - 03(2009)  
\(^{20}\) ASTM C834 - 10  
\(^{21}\) ASTM E136 - 09b
Topic: Attic Sealing
Subtopic: Attic Penetrations and Chases

5) Detail Name: Chase Capping

Desired Outcome:
- Chase capped to prevent air leakage and moisture movement between the attic and conditioned space

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-inspection</td>
<td>An inspection will be conducted for mold, water leaks and water damage before sealing a chase</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repairs will be completed before work begins</td>
<td>Repair moisture-related issues</td>
</tr>
<tr>
<td>2</td>
<td>Standard chase (walls covered with drywall or plaster)</td>
<td>Entire opening will be spanned with rigid material</td>
<td>Reduce opening to what can be sealed with sealant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Material will be cut to fit and fastened as required</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Non standard chase (walls covered with wood or paneling)</td>
<td>Material will be used that can be exposed to the interior of the house</td>
<td>Prevent a fire hazard</td>
</tr>
<tr>
<td>4</td>
<td>Support</td>
<td>Support material will be installed for spans wider than 24&quot;, except when air barrier material is rated to span greater distance under load (e.g., wind, insulation)</td>
<td>Ensure air seal stays in place and does not sag</td>
</tr>
<tr>
<td>5</td>
<td>Joint seal</td>
<td>Continuous seal will be installed around seams, cracks, joints, edges, penetrations and connections</td>
<td>Provide airtight, durable seal that does not move, bend or sag</td>
</tr>
</tbody>
</table>

22 ASTM E1186 - 03(2009)
|   | Adjacent framing | All remaining gaps at the top of the chase will be sealed | Ensure airtight seal from one finished side of the chase to the other |

23 ASTM E1186 - 03(2009)
### Topic: Attic Sealing

**Subtopic:** Open Stairwells

#### 6) Detail Name: Interior with Sloped Ceiling

**Desired Outcome:**
- Stairwells sealed to prevent air leakage and moisture movement between the attic and conditioned space

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-inspection</td>
<td>An inspection will be conducted for mold, water leaks and water damage before sealing an open stairwell</td>
<td>Repair moisture-related issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repairs will be completed before work begins</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Standard void over stairwell</td>
<td>Entire opening will be spanned with rigid material</td>
<td>Prevent air leakage from wall to attic</td>
</tr>
<tr>
<td></td>
<td>(15-minute fire-rated material; e.g., gypsum lined)</td>
<td>Material will be cut to fit and fastened as required</td>
<td>Reduce opening to what can be sealed with sealant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Support load as required (e.g., wind and insulation)</td>
</tr>
<tr>
<td>3</td>
<td>Non standard void over stairwell</td>
<td>Material will be used that can be exposed to the interior of the house</td>
<td>Prevent a fire hazard</td>
</tr>
<tr>
<td></td>
<td>(Surfaces around void are not 15-minute fire-rated (e.g., bookcases, chest of drawers), or lined with paneling or other non fire-rated material)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Support</td>
<td>Support material will be installed for spans wider than 24”, except when air barrier material is rated to span greater distance under load</td>
<td>Ensure air seal stays in place and does not sag</td>
</tr>
</tbody>
</table>

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24 ASTM E1186 - 03(2009)
25 ASTM E1186 - 03(2009)
<table>
<thead>
<tr>
<th></th>
<th>(e.g., wind, insulation)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td><strong>Joint seal</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continuous seal will be installed around seams, cracks, joints, edges, penetrations and connections</td>
<td>Provide airtight, durable seal that does not move, bend or sag 26</td>
</tr>
<tr>
<td>6</td>
<td><strong>Perimeter sealing</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Air barrier will be extended on all four sides from finished ceiling or existing framing to the new barrier</td>
<td>Create a continuous air barrier 27</td>
</tr>
<tr>
<td></td>
<td>Access will be gained as needed (e.g., pull flooring)</td>
<td></td>
</tr>
</tbody>
</table>

---

26 ASTM E1186 - 03(2009)

27 ASTM E1186 - 03(2009)
**Topic: Attic Sealing**

**Subtopic:** Penetrations and Chases

7) **Detail Name:** Pocket Door

**Desired Outcome:**
- Pocket door sealed to prevent leakage

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Backing and infill</td>
<td>Backing or infill will be provided as needed to meet the specific characteristics of the selected material and the characteristics of the hole. The infill will not bend, sag or move once installed.</td>
<td>Minimize hole size to ensure successful use of sealant. Ensure closure is permanent and supports any load (e.g. wind and insulation). Ensure sealant does not fall out.</td>
</tr>
<tr>
<td>2</td>
<td>Sealant selection</td>
<td>Sealants will be compatible with their intended surfaces. Sealants will be continuous and meet fire barrier specifications.</td>
<td>Select permanent sealant. Ensure sealant meets or exceeds the performance characteristics of the surrounding materials.</td>
</tr>
</tbody>
</table>

---

28 ASTM E1186 - 03(2009)
29 ASTM C834 - 10
## Topic: Attic Sealing
### Subtopic: Open Stairwells

8) **Detail Name:** Stairwell to Attic - Door at Bottom with No Ceiling Above

**Desired Outcome:**
- Stairwell sealed to prevent air leakage and moisture movement between the attic and conditioned space

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-inspection</td>
<td>An inspection will be conducted for mold, water leaks and water damage before sealing an open stairwell. Repairs will be completed before work begins.</td>
<td>Repair moisture-related issues</td>
</tr>
<tr>
<td>2</td>
<td><strong>Option 1</strong> Bring stairwell inside</td>
<td>Materials will be installed in line with the ceiling level with an airtight and operable insulated panel for repeated access. OR Airtight seal will be provided between level of new closure or cap and interior ceiling around perimeter. Access will be gained as needed (e.g., pull flooring)</td>
<td>Prevent air leakage through stairwell between conditioned space and attic. Support insulation. Bring the stairwell inside of the thermal boundary. Ensure the new closure ties into the existing air barrier on all sides</td>
</tr>
<tr>
<td>3</td>
<td><strong>Option 2</strong> Keep stairwell outside</td>
<td>An air barrier will be created and insulation material will be continuously installed across all surfaces of stairwell, including weather-stripped and insulated doors. OR</td>
<td>Prevent air leakage and provide continuous thermal boundary. Maximize thermal performance</td>
</tr>
</tbody>
</table>

---

30 ASTM E1186 - 03(2009)
31 ASTM E1186 - 03(2009)
32 ASTM E1186 - 03(2009)
|   |  **Support** | All cavities between stairs and conditioned space will be packed with an insulation material tested to resist air flow (e.g., walls, floors, landings, under stairs) 
Door will be weather stripped or insulated OR A combination of the above methods can be used |
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Support</td>
<td>Support material will be installed for spans wider than 24”, except when air barrier material is rated to span greater distance under load (e.g., wind, insulation) Ensure seal stays in place and does not sag</td>
</tr>
<tr>
<td>5</td>
<td>Joint seal</td>
<td>Continuous, airtight seals will be provided around seams, cracks, joints, edges, penetrations and connections Provide airtight, durable seal that does not move, bend or sag</td>
</tr>
</tbody>
</table>
| 6 | Perimeter sealing | Air barrier will be extended on all four sides from finished ceiling or the existing framing to the new barrier Create a continuous air barrier 33  
Access will be gained as needed (e.g., pull flooring) |

33 ASTM E1186 - 03(2009)
**Topic: Attic Sealing**  
**Subtopic:** Sealing Open Stairwells

9) **Detail Name:** Stairwell to Attic - Door at Bottom with No Ceiling Above

**Desired Outcome:**
- Stairwell sealed to prevent air leakage and moisture movement between the attic and conditioned space \(^{34}\)

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Pre-inspection | An inspection will be conducted for mold, water leaks and water damage before sealing an open stairwell  
Repairs will be completed before work begins | Repair moisture-related issues |
| 2   | Option 1  
Bring stairwell inside | Entire opening will be spanned with insulated and rigid material in line with the ceiling level with an airtight and operable insulated panel for repeated access  
OR  
Airtight seal will be provided between level of new closure or cap and interior ceiling around perimeter  
Access will be gained as needed (e.g., pull flooring) | Prevent air leakage through stairwell between conditioned space and attic \(^{35}\)  
Support insulation  
Bring the stairwell inside of the thermal envelope  
Ensure the new closure ties into the existing air barrier on all sides |
| 3   | Option 2  
Keep stairwell outside | An air barrier will be created and insulation material will be continuously installed across all surfaces of stairwell (walls and stairs), including weather stripped and insulated doors \(^{36}\) | Reduce leakage and provide continuous thermal boundary  
Maximize thermal performance |

\(^{34}\) ASTM E1186 - 03(2009)  
\(^{35}\) ASTM E1186 - 03(2009)  
\(^{36}\) ASTM E1186 - 03(2009)
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OR</strong></td>
<td><strong>OR</strong></td>
<td><strong>A combination of the above methods can be used</strong></td>
</tr>
<tr>
<td>All cavities between stairs and conditioned space will be packed with an insulation material tested to resist airflow (e.g., walls, floors, landings, under stairs)</td>
<td>Door will be weather stripped or insulated</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><strong>Support</strong></td>
<td>Support material will be installed for spans wider than 24” except when material is rated to span greater distance under load</td>
</tr>
<tr>
<td>5</td>
<td><strong>Joint seal</strong></td>
<td>Continuous, airtight seals will be provided around seams, cracks, joints, edges, penetrations and connections</td>
</tr>
<tr>
<td>6</td>
<td><strong>Perimeter sealing</strong></td>
<td>Air barrier will be extended on all four sides from finished ceiling or the existing framing to the new barrier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ensure air seal stays in place and does not sag</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide airtight, durable seal that does not move, bend or sag</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Create a continuous air barrier 37</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

37 ASTM E1186 - 03(2009)
Topic: Attic Sealing
Subtopic: Open Stairwells

10) Detail Name: Stairwell to Attic - Door at Top with Finished Ceiling Above

Desired Outcome:
- Stairwell is sealed to prevent air leakage and moisture movement between the attic and conditioned space \(^{38}\)

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Pre-inspection         | An inspection will be conducted for mold, water leaks and water damage before sealing an open stairwell  
Repairs will be completed before work begins   | Repair moisture-related issues                                                        |
| 2   | Option 1 Bring stairwell inside | An airtight seal will be provided between level of new closure or cap and interior ceiling around perimeter \(^{39}\)  
Access will be gained as needed (e.g., pull flooring)  
OR  
An air barrier will be created and insulation material will be continuously installed across all surfaces of stairwell, including weather stripped and insulated doors \(^{40}\)  
OR  
All cavities between stairs and conditioned space will be | Reduce air leakage and provide continuous thermal boundary  
Maximize thermal performance |

\(^{38}\) ASTM E1186 - 03(2009)  
\(^{39}\) ASTM E1186 - 03(2009)  
\(^{40}\) ASTM E1186 - 03(2009)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th>packed with an insulation material tested to resist air flow (e.g., walls, floors, landings, under stairs)</th>
</tr>
</thead>
</table>
|   |   | Door will be weather stripped and insulated  
**OR**  
A combination of the above methods can be used |
| 3 | Support | Support material will be installed for spans wider than 24”, except when air barrier material is rated to span greater distance under load (e.g., wind, insulation) |
|   |   | Ensure air seal stays in place and does not sag |
| 4 | Joint seal | Continuous, airtight seals will be provided around seams, cracks, joints, edges, penetrations and connections |
|   |   | Provide airtight, durable seal that does not move, bend or sag |
| 5 | Perimeter sealing | The air barrier will be extended on all four sides from finished ceiling or the existing framing to the new barrier  
Access will be gained as needed (e.g., pull flooring) |
|   |   | Create a continuous air barrier |
**Topic: Attic Sealing**

**Subtopic: Dropped Ceilings and Soffits**

11) **Detail Name:** Walls Open to Attic – Balloon Framing and Double Walls

**Desired Outcome:**
- Continuous air barrier created to prevent air leakage and moisture movement between the attic and conditioned space

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-inspection</td>
<td>An inspection will be conducted for mold, water leaks and water damage before sealing a dropped ceiling or soffit&lt;br&gt;Repairs will be completed before work begins</td>
<td>Repair moisture-related issues</td>
</tr>
<tr>
<td>2</td>
<td>Sealing methods</td>
<td>Entire opening will be spanned with rigid material in line with the ceiling level&lt;br&gt;Material will be cut to fit and fastened as required OR Wall below openings will be dense packed&lt;br&gt;Sealants will be used that prevent visible air movement using chemical smoke at 50 Pascals of pressure difference</td>
<td>Prevent air leakage from wall cavity to attic&lt;br&gt;42</td>
</tr>
<tr>
<td>3</td>
<td>Support</td>
<td>Support material will be installed for spans wider than 24”, except when air barrier material is rated to span greater distance under load (e.g., wind, insulation)</td>
<td>Ensure air seal stays in place and does not sag</td>
</tr>
</tbody>
</table>

41 ASTM E1186 - 03(2009)
42 ASTM E1186 - 03(2009)
<table>
<thead>
<tr>
<th></th>
<th><strong>Joint Seal</strong></th>
<th>Continuous seal will be installed around seams, cracks, joints, edges, penetrations and connections 43</th>
<th>Provide airtight, durable seal that does not move, bend or sag</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td><strong>Adjacent framing</strong></td>
<td>All remaining gaps at the top of the opening will be sealed</td>
<td>Ensure airtight seal from one finished side of the wall assembly to the other 44</td>
</tr>
</tbody>
</table>

43 ASTM C834 - 10  
44 ASTM E1186 - 03(2009)
**Topic: Attic Sealing**

**Subtopic: Dropped Ceilings and Soffits**

12) **Detail Name:** New Ceiling Below Original - Old Ceiling Intact or Repairable

**Desired Outcome:**
- Continuous air barrier created to prevent air leakage and moisture movement between the attic and conditioned space

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Pre-inspection | An inspection will be conducted for mold, water leaks and water damage before sealing a dropped ceiling or soffit  
Repairs will be completed before work begins                                                                                          | Repair moisture-related issues                                                |
| 2   | Sealing methods| Entire opening will be spanned with rigid material in line with the ceiling level  
Material will be cut to fit and fastened as required  
OR  
Side of stud bays will be sealed with rigid material from bottom of dropped ceiling to top-plate  
OR  
Wall below openings will be dense packed  
Seals will be used that prevent visible air movement using chemical smoke at 50 Pascals of pressure difference | Prevent air leakage from dropped ceiling to attic 47                           |

45 ASTM C1015 - 06  
46 ASTM E1186 - 03(2009)  
47 ASTM E1186 - 03(2009)
<table>
<thead>
<tr>
<th>3</th>
<th><strong>Support</strong></th>
<th>Support material will be installed for spans wider than 24”, except when air barrier material is rated to span greater distance under load (e.g., wind, insulation)</th>
<th>Ensure air seal stays in place and does not sag</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td><strong>Joint seal</strong></td>
<td>Continuous seal will be installed around seams, cracks, joints, edges, penetrations and connections[^48]</td>
<td>Provide airtight, durable seal that does not move, bend or sag</td>
</tr>
<tr>
<td>5</td>
<td><strong>Adjacent framing</strong></td>
<td>All remaining gaps will be sealed at the top of the dropped ceiling</td>
<td>Provide airtight framing from one finished side of the dropped ceiling to the other[^49]</td>
</tr>
</tbody>
</table>

[^48]: ASTM C834 - 10
[^49]: ASTM E1186 - 03(2009)
**Topic: Attic Sealing**

**Subtopic: Dropped Ceilings and Soffits**

13) **Detail Name:** Above Closets and Tubs

**Desired Outcome:**
- Continuous air barrier created to prevent air leakage and moisture movement between the attic and conditioned space

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Pre-inspection         | An inspection will be conducted for mold, water leaks and water damage before sealing a dropped ceiling or soffit  
Repairs will be completed before work begins | Repair moisture-related issues                                                            |
| 2   | Above closets and tubs | Entire opening will be spanned with rigid material in line with the ceiling level  
Material will be cut to fit and fastened as required  
**OR**  
Side of stud bays will be sealed with rigid material from bottom of dropped ceiling to top-plate  
**OR**  
Wall below openings will be dense packed  
Seals will be used that prevent visible air movement using chemical smoke at 50 Pascals of pressure difference | Prevent air leakage from dropped ceiling to attic  
52                                                                                     |

50 ASTM C1015 - 06  
51 ASTM E1186 - 03(2009)  
52 ASTM E1186 - 03(2009)
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td><strong>Support</strong></td>
<td>Support material will be installed for spans wider than 24”, except when air barrier material is rated to span greater distance under load (e.g., wind, insulation)</td>
</tr>
<tr>
<td>4</td>
<td><strong>Joint seal</strong></td>
<td>Continuous seal will be installed around seams, cracks, joints, edges, penetrations and connections 53</td>
</tr>
<tr>
<td>5</td>
<td><strong>Adjacent framing</strong></td>
<td>All remaining gaps at the top of the dropped ceiling will be sealed</td>
</tr>
</tbody>
</table>

53 ASTM C834 - 10
54 ASTM E1186 - 03(2009)
### Topic: Attic Sealing  
**Subtopic:** Dropped Ceilings and Soffits

#### 14) Detail Name: Ceiling Leaks Not Repairable - No Air Barrier Above

**Desired Outcome:**
- Continuous air barrier created to prevent air leakage and moisture movement between the attic and conditioned space.  

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-inspection</td>
<td>An inspection will be conducted for mold, water leaks and water damage before sealing a dropped ceiling or soffit</td>
<td>Repair moisture-related issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repairs will be completed before work begins</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Sealing methods</td>
<td>Ceiling or roof and wall air and thermal barriers will be connected with a rigid airtight connection around the perimeter.</td>
<td>Prevent air leakage from dropped ceiling to attic.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>If ceiling will support an air barrier and insulation, a rigid airtight barrier (e.g., gypsum) will be attached to current ceiling either above or below.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intermediate framing will be used to support air and thermal barrier.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rigid airtight thermal barrier will be installed at the roof sheathing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seals will be used that prevent visible air movement using</td>
<td></td>
</tr>
</tbody>
</table>

\[55\] ASTM E1186 - 03(2009)  
\[56\] ASTM E1186 - 03(2009)  
\[58\]
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>chemical smoke at 50 Pascals of pressure difference</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Support</td>
<td>Support material will be installed for spans wider than 24”, except when air barrier material is rated to span greater distance under load (e.g., wind, insulation)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ensure air seal stays in place and does not sag</td>
</tr>
<tr>
<td>4</td>
<td>Joint seal</td>
<td>Continuous seal will be installed around seams, cracks, joints, edges, penetrations and connections</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide airtight, durable seal that does not move, bend or sag</td>
</tr>
<tr>
<td>5</td>
<td>Adjacent framing</td>
<td>All remaining gaps will be sealed at the top of the dropped ceiling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide airtight framing from one finished side of the dropped ceiling to the other</td>
</tr>
</tbody>
</table>

58 ASTM E1186 - 03(2009)
57 ASTM E1186 - 03(2009)
59 ASTM C834 - 10
60 ASTM E1186 - 03(2009)
**Topic: Attic Sealing**

**Subtopic: Dropped Ceilings and Soffits**

**15) Detail Name: 3-D Walls**

**Desired Outcome:**
- Continuous air barrier created to prevent air leakage and moisture movement between the attic and conditioned space

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Pre-inspection | An inspection will be conducted for mold, water leaks and water damage before sealing a dropped ceiling or soffit  
|     |                | Repairs will be completed before work begins                                     | Repair moisture-related issues                    |
| 2   | Sealing methods| Entire opening will be spanned with rigid material installed in line with the ceiling level  
|     |                | Material will be cut to fit and fastened as required  
|     |                | OR  
|     |                | Side of stud bays will be sealed with rigid material from bottom of dropped ceiling to top-plate  
|     |                | OR  
|     |                | Wall below openings will be dense packed  
|     |                | Seals will be used that prevent visible air movement using chemical smoke at 50 Pascals of | Prevent air leakage from dropped ceiling to attic  |

61 ASTM C1015 - 06
63 ASTM E1186 - 03(2009)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th>pressure difference $^{62}$</th>
</tr>
</thead>
</table>
| 3 | Support | Support material will be installed for spans wider than 24” except when air barrier material is rated to span greater distance under load (e.g., wind, insulation)  
Ensure air seal stays in place and does not sag |
| 4 | Joint Seal | Continuous seal will be installed around seams, cracks, joints, edges, penetrations and connections $^{64}$  
Provide airtight, durable seal that does not move, bend or sag |
| 5 | Adjacent framing | All remaining gaps will be sealed at the top of the dropped ceiling  
Provide airtight framing from one finished side of the dropped ceiling to the other $^{65}$ |

$^{62}$ ASTM E1186 - 03(2009)  
$^{64}$ ASTM C834 - 10  
$^{65}$ ASTM E1186 - 03(2009)
# Topic: Attic Sealing

**Subtopic:** Dropped Ceilings and Soffits

## 16) Detail Name: Dropped Ceiling with Light Boxes and Fixtures

**Desired Outcome:**
- Light boxes sealed to safely prevent air leakage and moisture movement between the attic and conditioned space

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-inspection</td>
<td>An inspection will be conducted for mold, water leaks and water damage before sealing a dropped ceiling or soffit</td>
<td>Repair moisture-related issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repairs will be completed before work begins</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Light boxes (e.g., fluorescent lights)</td>
<td>An airtight seal will be provided around perimeter between light box enclosure and interior ceiling</td>
<td>Prevent air leakage $^{68}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All seams and penetrations of the enclosure will be sealed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Access will be gained as needed (e.g., pull flooring) $^{66}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seals will be used that prevent visible air movement using chemical smoke at 50 Pascals of pressure difference $^{67}$</td>
<td></td>
</tr>
</tbody>
</table>

$^{66}$ ASTM E1186 - 03(2009)  
$^{67}$ ASTM E1186 - 03(2009)  
$^{68}$ ASTM E1186 - 03(2009)
| 3 | **Non-insulation contact (IC) rated recessed lights** | Insulation will be kept at least 3” away from the top and side of any fixtures.  

If dropped ceiling is to be filled with insulation, then a sealed rigid barrier enclosure will be installed to maintain a 3” clearance on all sides and at least ½” from combustible materials.  

Top of rigid barrier enclosure will be sealed with non-insulating rigid material (e.g., gypsum or equivalent perm rating and R-value). |

|   |   | Prevent light fixture from overheating  

Bring the light fixture inside of the air barrier |

---

69 ASTM C1015 - 06  
70 ASTM C1015 - 06  
71 ASTM E1186 - 03(2009)
**Topic: Attic Sealing**

**Subtopic: Dropped Ceilings and Soffits**

17) **Detail Name:** Dropped Soffits

**Desired Outcome:**
- Dropped soffits sealed to prevent air leakage and moisture movement between the attic and conditioned space

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-inspection</td>
<td>An inspection will be conducted for mold, water leaks and water damage before sealing a dropped ceiling or soffit. Repairs will be completed before work begins.</td>
<td>Repair moisture-related issues</td>
</tr>
<tr>
<td>2</td>
<td>Soffit general</td>
<td>Air flow will be blocked at soffit in locations where access allows.</td>
<td>Provide continuous air barrier across soffit openings</td>
</tr>
<tr>
<td>3</td>
<td>Option 1</td>
<td>Entire opening will be spanned with rigid material in line with the ceiling level. Material will be cut to fit and fasten as required.</td>
<td>Prevent air leakage from wall to attic. Reduce opening to what can be sealed with sealant. Support load as required (e.g., wind and insulation). Bring the soffit into the thermal boundary.</td>
</tr>
<tr>
<td>4</td>
<td>Option 2</td>
<td>Each stud bay will be spanned with rigid material.</td>
<td>Prevent air leakage from wall to soffit. Reduce opening to what can be sealed with sealant.</td>
</tr>
</tbody>
</table>

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72 ASTM E1186 - 03(2009)
73 ASTM E1186 - 03(2009)
74 ASTM E1186 - 03(2009)
75 ASTM E1186 - 03(2009)
<table>
<thead>
<tr>
<th>5</th>
<th><strong>Soffits containing non-insulation contact (IC) rated recessed lights</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Material will be cut to fit and fastened as required</td>
</tr>
<tr>
<td></td>
<td><strong>OR</strong></td>
</tr>
<tr>
<td></td>
<td>Backing at each stud bay will be provided and will sealed</td>
</tr>
<tr>
<td></td>
<td><strong>OR</strong></td>
</tr>
<tr>
<td></td>
<td>Side of stud bays will be sealed with rigid material from bottom of soffit to top-plate</td>
</tr>
<tr>
<td></td>
<td><strong>OR</strong></td>
</tr>
<tr>
<td></td>
<td>A sealed rigid barrier will be installed at all transitions</td>
</tr>
<tr>
<td></td>
<td>be sealed with sealant</td>
</tr>
<tr>
<td></td>
<td>Ensure soffit is outside of the thermal boundary</td>
</tr>
</tbody>
</table>

Insulation will be kept at least 3” away from the top and side of any fixtures.

If dropped soffit is to be filled with insulation, then a sealed rigid barrier enclosure will be installed to maintain a 3” clearance on all sides and at least ½” from combustible materials.  

Top of rigid barrier enclosure will be sealed with non-insulating rigid material (e.g., gypsum or equivalent perm rating and R-value).

Prevent light fixture from overheating.

Bring the light fixture inside of the air barrier.

---

76 ASTM C1015 - 06
Topic: Attic Sealing  
Subtopic: Other Ceiling Types

18) Detail Name: Tongue and Groove Ceilings

Desired Outcome:
- Tongue and groove ceilings sealed to prevent air leakage and moisture movement between the attic and conditioned space

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-inspection</td>
<td>An inspection will be conducted for mold, water leaks and water damage before sealing a tongue and groove ceiling</td>
<td>Repair moisture-related issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repairs will be completed before work</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Backing</td>
<td>Backing will be installed behind tongue and groove ceilings</td>
<td>Prevent air leakage and allow for sealants</td>
</tr>
<tr>
<td>3</td>
<td>Sealant selection</td>
<td>Sealants will be compatible with their intended surfaces</td>
<td>Select permanent sealant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sealants will be continuous and meet fire barrier specifications</td>
<td>Ensure sealant meets or exceeds the performance characteristics of the surrounding materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No sealant will be allowed to be visible in the living space</td>
<td>Ceiling remains aesthetically pleasing</td>
</tr>
</tbody>
</table>

77 ASTM C1193 - 09
# Topic: Attic Sealing

## Subtopic: Other Ceiling Types

19) **Detail Name:** Cathedralized Attic Ceilings

**Desired Outcome:**
- Cathedralized attics sealed to prevent air leakage

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-inspection</td>
<td>An inspection will be conducted for mold, water leaks and water damage before sealing a cathedralized ceiling&lt;br&gt;Repairs will be completed before work begins</td>
<td>Repair moisture-related issues</td>
</tr>
<tr>
<td>2</td>
<td>Backing and infill</td>
<td>Backing or infill will be provided as needed to meet the specific characteristics of the selected material and the characteristics of the open space&lt;br&gt;The infill or backing will not bend, sag or move once installed</td>
<td>Minimize hole size to ensure successful use of sealant&lt;br&gt;Ensure closure is permanent and supports and load (e.g., wind and insulation)&lt;br&gt;Ensure sealant does not fall out</td>
</tr>
<tr>
<td>3</td>
<td>Sealant selection 78</td>
<td>Sealants will be compatible with their intended surfaces&lt;br&gt;Sealants will be continuous and meet fire barrier specifications</td>
<td>Select permanent sealant&lt;br&gt;Ensure sealant meets or exceeds the performance characteristics of the surrounding materials</td>
</tr>
</tbody>
</table>

---

78 ASTM C1193 - 09
## Topic: Attic Sealing
### Subtopic: Special Considerations

20) **Detail Name:** Regional Consideration

<table>
<thead>
<tr>
<th>Row</th>
<th>Region</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very Cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Cold</td>
<td>Hydrophobic sealants will be used in all attic sealing details</td>
<td>Increase durability of seal</td>
</tr>
<tr>
<td>3</td>
<td>Mixed Humid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Hot Humid</td>
<td>Plastic, foil, or any other Class 1 vapor barrier will not be used</td>
<td>Avoid moisture-related damage to the house</td>
</tr>
<tr>
<td>5</td>
<td>Marine</td>
<td>Vapor permeable materials will be used to block and seal penetrations in attic</td>
<td>Avoid moisture-related damage to the house</td>
</tr>
<tr>
<td>6</td>
<td>Hot Dry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

79 ASTM C1193 - 09  
80 ASTM E241 - 09  
81 ASTM C1193 - 09
Garage Sealing

Garage Openings:
   21) Penetrations, Cracks and Doors between Garage and House
## Topic: Garage Sealing
### Subtopic: Garage Openings

21) **Detail Name:** Penetrations, Cracks and Doors between Garage and House

**Desired Outcome:**
- Openings from garage sealed to prevent leakage

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Penetrations</td>
<td>All lighting fixtures, wiring, plumbing, venting, ducting and gas piping penetrations will be sealed  (^{82})</td>
<td></td>
</tr>
</tbody>
</table>
| 2   | Cracks                       | All cracks in house and garage separation wall will be sealed, including cracks between mud sill, rim joists, subfloors and bottom of gypsum board
All cracks in ceiling surfaces will be sealed  \(^{83}\)                                                                                     | Prevent air leakage and pollutant entry           |
| 3   | Garage to house door         | Weatherstripping, door sweep or threshold will be installed to stop air leakage                                                                                                                                   |                                                  |
| 4   | Glass                        | Broken glass panes in doors will be replaced, pointed and glazed where needed                                                                                                                                  |                                                  |
| 5   | Carbon monoxide (CO) detector| In all homes with an attached garage, at least one CO detector will be installed per floor                                                                                                                                 | Prevent CO exposure to occupants from attached garage |

\(^{82}\) ASTM C1193 - 09  
\(^{83}\) ASTM C1193 - 09
**Window and Door Sealing**

**Maintenance and Repair:**
22) Double-Hung Wood Windows  
23) Single-Unit Window and Fixed Frame with Wood Sash  
24) Exterior Doors

**Cracked and Broken Glass:**
25) Fixed Frame with Wood Sash — Older House  
26) Single-Unit Window, Mounted on Rough Opening — Newer House

**Replacement:**
27) Fixed Frame with Wood Sash — Older House  
28) Single-Unit Window, Mounted on Rough Opening — Newer House
## Topic: Windows and Doors

**Subtopic:** Maintenance and Repair

### 22) Detail Name: Double-Hung Wood Windows

**Desired Outcome:**
- Windows operable and weather tight

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Lead paint assessment | Presence of lead based paint in pre-1978 homes will be assumed unless testing confirms otherwise  
Comply with EPA’s Renovation, Repair and Painting (RRP) Program Rule (40 CFR Part 745) in pre-1978 homes and proposed changes to this rule (Federal Register/Vol. 75, No. 87/ May 6, 2010), to be superseded by any subsequent final rulemaking or any more stringent state or federal standards | Protect worker and occupant from potential lead hazards                                                                                                                                                                                                                 |
| 2   | Weatherstripping       | Existing weatherstripping and sash sealant will be removed  
Surface where the sill meets the sash will be cleaned  
Seal between the fixed components of the window (e.g., jambs, sill) will be continuous and complete while maintaining the operability of the window  
Continuous and complete weatherstripping will be installed on the bottom of the window | Form a complete seal from the outer edge of the sash to the jamb  
Maintain operability of the window                                                                                                                                                                                                                                   |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th>lower sash where it makes contact with the sill and at the top of the upper sash where it makes contact with the upper part of the window frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Sash locks</td>
<td>Locks will be installed so that the rails of the upper and lower sashes are flush and in full contact. No gaps will be visible between the two sashes. Locks will be installed to achieve compression of the two sashes. Form a secure connection between the two sashes.</td>
</tr>
<tr>
<td>4</td>
<td>Replacement sills</td>
<td>Beveled sill will be flush with interior wall and sloped to the exterior. Seams will be continuously and completely sealed with sealant to the jambs and to the frame. Sill will be water-sealed and primed. Form a complete seal from the bottom of the lower sash to the sill. Maintain operability of the window. Allow for drainage to the exterior.</td>
</tr>
<tr>
<td>5</td>
<td>Sash replacement</td>
<td>Lower sash will have the same bevel on the bottom rail as the sill. The sash will be water-sealed and primed. Ensure sash remains in a fixed position when open or partially open. Maintain operability of the window.</td>
</tr>
<tr>
<td>6</td>
<td>Adjust stops</td>
<td>Stops will be adjusted to eliminate visible gaps between the stops and the jamb while maintaining operability of the window. Form a complete seal between the jamb, sash and stop. Maintain operability of the window.</td>
</tr>
<tr>
<td>7</td>
<td>Replace stops</td>
<td>Stops will be installed to keep the window securely in place. Stops will be adjusted to maintain operability of the window. Form a complete seal between the jamb, sash and stop. Maintain operability of the window.</td>
</tr>
<tr>
<td>eliminate visible gaps between the stops and the jamb while maintaining operability of the window</td>
<td>window</td>
<td></td>
</tr>
</tbody>
</table>
**Topic: Windows and Doors**

**Subtopic:** Maintenance and Repair

23) **Detail Name:** Single-Unit Window and Fixed Frame with Wood Sash

**Desired Outcome:**
- Windows operable and weather tight

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lead paint assessment</td>
<td>Presence of lead based paint in pre-1978 homes will be assumed unless testing confirms otherwise</td>
<td>Protect worker and occupant from potential lead hazards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comply with EPA’s Renovation, Repair and Painting (RRP) Program Rule (40 CFR Part 745) in pre-1978 homes and proposed changes to this rule (Federal Register/Vol. 75, No. 87/ May 6, 2010), to be superseded by any subsequent final rulemaking or any more stringent state or Federal standards</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Operable windows</td>
<td>All egress windows will be operable as required by local codes</td>
<td>Ensure all egress windows are operable</td>
</tr>
<tr>
<td>3</td>
<td>Air infiltration</td>
<td>Details that reduce air infiltration will be repaired, replaced or installed (e.g., new latch for meeting rail connection, pulley seals, rope caulking for other cracks, interior storm windows)</td>
<td>Reduce air infiltration</td>
</tr>
<tr>
<td>4</td>
<td>Water infiltration</td>
<td>Details that reduce water infiltration will be repaired, replaced or installed (e.g., replace missing glazing)</td>
<td>Reduce water infiltration</td>
</tr>
<tr>
<td></td>
<td>compound on sash, exterior caulking, exterior storm windows)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><strong>Occupant education and maintenance</strong></td>
<td>Occupants will be notified of changes or repairs made and educated on how to operate and maintain window</td>
<td>Ensure long-term weather tightness</td>
</tr>
</tbody>
</table>
## Topic: Windows and Doors
### Subtopic: Maintenance and Repair

**24) Detail Name:** Exterior Doors

**Desired Outcome:**
- Doors operable and weather tight

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lead paint assessment</td>
<td>Presence of lead based paint in pre-1978 homes will be assumed unless testing confirms otherwise. Comply with EPA’s Renovation, Repair and Painting (RRP) Program Rule (40 CFR Part 745) in pre-1978 homes and proposed changes to this rule (Federal Register/Vol. 75, No. 87/ May 6, 2010), to be superseded by any subsequent final rulemaking or any more stringent state or Federal standards.</td>
<td>Protect worker and occupant from potential lead hazards</td>
</tr>
<tr>
<td>2</td>
<td>Door operation and fit</td>
<td>The door will be adjusted to properly fit the jamb and allow for ease of operation (e.g., hinge replacement, replane door, door strike adjustment)</td>
<td>Ensure proper operation of the door</td>
</tr>
<tr>
<td>3</td>
<td>Air infiltration</td>
<td>Details that reduce air infiltration will be repaired, replaced or installed (e.g., weatherstripping, door bottoms, trim replacement with foam)</td>
<td>Reduce air infiltration</td>
</tr>
<tr>
<td>4</td>
<td>Water infiltration</td>
<td>Details that reduce water infiltration will be repaired, replaced or installed (e.g., adjust threshold, caulk jamb)</td>
<td>Reduce water infiltration</td>
</tr>
<tr>
<td></td>
<td>Occupant education and maintenance</td>
<td>Occupants will be notified of changes or repairs made and educated on how to operate and maintain weatherstripping and caulk around door and trim</td>
<td>Ensure long-term weather tightness</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>5</td>
<td>to threshold, caulk trim, flashing)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Topic: Windows and Doors

## Subtopic: Cracked and Broken Glass

### 25) Detail Name: Fixed Frame with Wood Sash — Older House

**Desired Outcome:**
- Glass complete and intact

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Lead paint         | Presence of lead based paint in pre-1978 homes will be assumed unless testing confirms otherwise.  
Comply with EPA’s Renovation, Repair and Painting (RRP) Program Rule (40 CFR Part 745) in pre-1978 homes and proposed changes to this rule (Federal Register/Vol. 75, No. 87/ May 6, 2010), to be superseded by any subsequent final rulemaking or any more stringent state or Federal standards. | Protect worker and occupant from potential lead hazards                                               |
| 2   | Broken glass removal | Putty and push points will be removed  
Broken or cracked glass will be removed | Safely remove old glass                                                                                       |
| 3   | Sash preparation   | Opening will be cleaned | Prepare opening for new glass                                                                 |
| 4   | New glass installation | Glass will be sized 1/8” to 3/16” smaller than opening to allow for movement of frame  
Safety glass will be installed as required by local codes  
Push points will be provided on each side to secure glass in | Ensure glazing compound will adhere to sash  
Install, seal and secure new glass in place  
Allow glazing compound to harden to ensure secure installation |
<table>
<thead>
<tr>
<th>frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sash will be primed before installing new glass</td>
</tr>
<tr>
<td>A glazing compound will be added</td>
</tr>
<tr>
<td>Glazing compound will be allowed to set for 24 hours before cleaning or applying pressure</td>
</tr>
</tbody>
</table>
### Topic: Windows and Doors
**Subtopic:** Cracked and Broken Glass

#### 26) Detail Name: Single-Unit Window, Mounted on Rough Opening — Newer House

**Desired Outcome:**
- Glass complete and intact

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lead paint assessment</td>
<td>Presence of lead based paint in pre-1978 homes will be assumed unless testing confirms otherwise</td>
<td>Protect worker and occupant from potential lead hazards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comply with EPA’s Renovation, Repair and Painting (RRP) Program Rule (40 CFR Part 745) in pre-1978 homes and proposed changes to this rule (Federal Register/Vol. 75, No. 87/ May 6, 2010), to be superseded by any subsequent final rulemaking or any more stringent state or Federal standards</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Broken glass removal</td>
<td>Window stops and damaged glass will be removed</td>
<td>Safely remove old glass</td>
</tr>
<tr>
<td>3</td>
<td>Opening preparation</td>
<td>Opening will be cleaned</td>
<td>Prepare opening for new glass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Glazing tape will be removed or replaced</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>New glass installation</td>
<td>Replacement glass will be sized to original width, height and depth</td>
<td>Install, seal and secure new glass in place</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stops will be replaced or installed</td>
<td>Allow glazing compound to harden to ensure secure installation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wood stops will be sealed to glass with appropriate sealant</td>
<td></td>
</tr>
<tr>
<td>Glazing project requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass will be selected with comparable tint and coating (color and look)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety glass will be installed as required by local codes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glazing compound will be allowed to set for 24 hours before cleaning or applying pressure</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Topic: Windows and Doors
#### Subtopic: Replacement

27) **Detail Name:** Fixed Frame with Wood Sash — Older House

**Desired Outcome:**
- Replacement window provides weathertight fit

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
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<th>Objective(s)</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>Lead paint assessment</td>
<td>Presence of lead based paint in pre-1978 homes will be assumed unless testing confirms otherwise&lt;br&gt;Comply with EPA’s Renovation, Repair and Painting (RRP) Program Rule (40 CFR Part 745) in pre-1978 homes and proposed changes to this rule (Federal Register/Vol. 75, No. 87/ May 6, 2010), to be superseded by any subsequent final rulemaking or any more stringent state or Federal standards</td>
<td>Protect worker and occupant from potential lead hazards</td>
</tr>
<tr>
<td>2</td>
<td>Opening preparation</td>
<td>Interior stops, sashes, parting strips and pulleys will be removed&lt;br&gt;Opening will be cleaned</td>
<td>Provide a clean opening for replacement window unit</td>
</tr>
<tr>
<td>3</td>
<td>Replacement window installation</td>
<td>New window will be adjusted to allow for good fit and finish as well as proper operation&lt;br&gt;Weight pockets will be sealed and insulated&lt;br&gt;Gaps between the new window and existing frame will be sealed with low expanding foam</td>
<td>Ensure replacement window operates properly&lt;br&gt;Ensure replacement window has a weathertight fit</td>
</tr>
<tr>
<td></td>
<td>Safety</td>
<td>Occupant education and maintenance</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---------------------------</td>
<td>-------------------------------------</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Window will be secured with stops&lt;br&gt;Gap between the bottom of the replacement window and exterior sill will be filled with trim&lt;br&gt;Replacement window will be caulked to exterior stops</td>
<td>Egress windows and safety glass will be installed as required by local codes</td>
<td>Meet all codes when replacing windows</td>
</tr>
<tr>
<td>5</td>
<td>Occupants will be notified of changes or repairs made and educated on how to operate and maintain window</td>
<td>Ensure long-term weather tightness</td>
<td></td>
</tr>
</tbody>
</table>
**Topic: Windows and Doors**

**Subtopic:** Replacement

**28) Detail Name:** Single-Unit Window, Mounted on Rough Opening — Newer House

**Desired Outcome:**
- Replacement window provides weathertight fit

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lead paint assessment</td>
<td>Presence of lead based paint in pre-1978 homes will be assumed unless testing confirms otherwise. Comply with EPA’s Renovation, Repair and Painting (RRP) Program Rule (40 CFR Part 745) in pre-1978 homes and proposed changes to this rule (Federal Register/Vol. 75, No. 87/ May 6, 2010), to be superseded by any subsequent final rulemaking or any more stringent state or Federal standards</td>
<td>Protect worker and occupant from potential lead hazards</td>
</tr>
<tr>
<td>2</td>
<td>Opening preparation</td>
<td>Replacement window will be laid out with trim. Exterior trim will be removed, or exterior siding will be cut back to fit new window with trim. Existing window will be removed. Window opening will be flashed according accepted industry standards.</td>
<td>Provide a clean and properly flashed opening for replacement window unit</td>
</tr>
<tr>
<td></td>
<td>Replacement unit preparation</td>
<td>Mounting detail will be determined based on depth of window and location of window liner</td>
<td>Allow for good fit and finish of replacement window</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Replacement window installation</td>
<td>Replacement window will be integrated with flashing&lt;br&gt;Gaps between the new window and existing frame will be sealed with low expanding foam&lt;br&gt;Proper operation, fit and finish will be checked&lt;br&gt;Adjustments will be made as necessary&lt;br&gt;Replacement window will be secured with fasteners according to accepted industry standards&lt;br&gt;New window trim will be back caulked to exterior sheathing&lt;br&gt;New window trim will be caulked to siding and window frame&lt;br&gt;Interior details will be caulked as necessary</td>
<td>Ensure replacement window operates properly&lt;br&gt;Ensure replacement window is weather tight</td>
</tr>
<tr>
<td>5</td>
<td>Safety</td>
<td>Egress windows and safety glass will be installed as required by local codes</td>
<td>Meet all codes when replacing windows</td>
</tr>
<tr>
<td>6</td>
<td>Occupant education and maintenance</td>
<td>Occupant will be notified of changes or repairs made and educated on how to operate and maintain window</td>
<td>Ensure long-term weather tightness</td>
</tr>
</tbody>
</table>
SECTION 5: HEATING AND COOLING

Table of Contents

Health and Safety

Safe Work Practices: 1
   1) Heating and Cooling Worker Safety

Forced Air

Design:
   2) Load Calculation and Equipment Selection
   3) Ductwork and Termination Design

Equipment Installation:
   4) Preparation for New Equipment
   5) Fuel Delivery System for Fuel Oil
   6) Fuel Delivery System for Natural Gas and Propane
   7) Setting of Air Handler
   8) Duct System
   9) Heating and Cooling Controls
  10) Venting System
  11) Condensate Drainage of Heating and Air Conditioning Equipment
  12) Regional Considerations

Commissioning of Equipment:
   13) Leak Detection
   14) Data Plate Verification
   15) Venting System
   16) Combustion Analysis
   17) Air Flow
   18) Electrical Service
   19) Refrigerant Line Inspection
   20) Sequence of Operation
   21) Occupant Education
   22) Evaporative Cooler Maintenance and Repairs
   23) Regional Considerations

1 Appendix D – OSHA Personal Protective Equipment Standards
Ducts

Duct Sealing:
24) Preparation and Mechanical Fastening
25) Support
26) Sealing System
27) Proprietary Spray Application
28) Sealing System Components
29) Return – Framed Platform
30) Dual Cooling Up Ducts
31) Removing Supply Vents From Garages

Duct Insulation:
32) Insulating Flex Ducts
33) Insulating Metal Ducts

Hydronic Heating

Design:
34) Heat Load Calculation – Whole House
35) Space Load Calculation – Heat Emitter Sizing

Equipment:
36) Boiler – Pressure Relief Safety Valve
37) Boiler Replacement – Gas and Oil
38) Controls – Thermostat Replacement

Maintenance:
39) Gas Boiler – Annual Service
40) Checklist
Health and Safety

Safe Work Practices:
   1) Heating and Cooling Worker Safety
**Topic: Health and Safety**  
**Subtopic: Safe Work Practices**

1) **Detail Name:** Heating and Cooling Worker Safety

**Desired Outcome:**
- Work completed safely without injury or hazardous exposure

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objectives(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hand protection</td>
<td>Durable and wrist protecting gloves will be worn that can withstand work activity</td>
<td>Minimize skin contact with contaminants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thermal gloves will be worn when dealing with liquid nitrogen</td>
<td>Protect hands from sharp objects</td>
</tr>
<tr>
<td>2</td>
<td>Respiratory protection</td>
<td>Respirators appropriate for the contaminants present will be worn (e.g., N-95 or equivalent face mask)</td>
<td>Minimize exposure to airborne contaminants (e.g., insulation materials, mold spores, feces, bacteria, chemicals)</td>
</tr>
<tr>
<td>3</td>
<td>Electrical safety</td>
<td>An electrical safety assessment will be performed</td>
<td>Avoid electrical shock and arc flash hazards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All electric tools will be protected by Ground-Fault Circuit Interrupters</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Extension cords used with portable electric tools will be of three-wire type</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Worn or frayed electric cords will not be used</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metal ladders will be avoided</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water, such as condensate</td>
<td></td>
</tr>
</tbody>
</table>

2 OSHA Technical Manual Section VIII: Chapter 1, part III  
3 OSHA Technical Manual Section VIII: Chapter 2, section IV  
5 29 CFR 1926 Subpart K – Electrical  
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| **4** | **Protective clothing** | pans, and electrical sources will be kept separate  
Special precautions will be taken to avoid electrical shock if knob and tube wiring is present  
For arc flash hazards, NFPA 70E will be consulted |
|   |   | If contaminants are present, (e.g., insulation materials) removable protective clothing will be worn  
Eye protection will be worn (e.g., safety glasses, goggles if not using full face respirator)  
Long sleeves and long pants may be worn as additional protection from liquid nitrogen and other skin hazards |
|   |   | Protect worker from skin contact with contaminants (e.g., insulation materials)  
Minimize spread of contaminants |
| **5** | **Confined space safety** 8,9 | Access and egress points will be located before beginning work  
Inspection will be conducted for frayed electrical wires  
Adequate ventilation will be provided  
Use of toxic material will be reduced |
|   |   | Prevent build-up of toxic or flammable contaminants  
Provide adequate access and egress  
Avoid electrical shock |

---

7 OSHA Technical Manual Section VIII: Chapter 1, part III  
8 ASTM D4276 - 02(2007)  
<table>
<thead>
<tr>
<th></th>
<th><strong>Power tool safety</strong></th>
<th>Power tools will be inspected and used in accordance with manufacturer specifications to eliminate hazards associated with missing ground prongs, ungrounded circuits, and misuse of power tools, noise, and improper or defective cords or extension cords. All devices used will be verified as GFI protected or double insulated.</th>
<th>Prevent power tool injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Chemical safety</strong></td>
<td>The least toxic suitable material will be chosen. Chemicals will be handled according to manufacturer specifications or Material Safety Data Sheet (MSDS) standards to eliminate hazards associated with volatile organic compounds (VOCs), sealants, insulation, contaminated drywall, dust, foams, asbestos, lead, mercury, fibers and oil tank mercury.</td>
<td>Prevent worker exposure to toxic substances</td>
</tr>
<tr>
<td></td>
<td><strong>Ergonomic safety</strong></td>
<td>Proper equipment will be used for work. Proper lifting techniques will be used. Personal Protective Equipment will be used (e.g., knee pads, bump caps, additional padding).</td>
<td>Avoid injuries from awkward postures, repetitive motions and improper lifting</td>
</tr>
<tr>
<td></td>
<td><strong>Hand tool safety</strong></td>
<td>Hand tools will be used for intended purpose.</td>
<td>Reduce injuries</td>
</tr>
</tbody>
</table>

---

10 29 CFR 1910 Subpart P - Hand and portable powered tools and other hand-held equipment
11 29 CFR 1910 Subpart Z - Toxic and Hazardous Substances
13 29 CFR 1910 Subpart P - Hand and portable powered tools and other hand-held equipment
| 10 | Slips, trips and falls | Caution will be used around power cords, hoses, tarps and plastic sheeting  
Precautions will be taken when working on ladders, when working at heights or balancing on joists  
Walk boards will be used when practical  
Appropriate footwear and clothing will be worn | Eliminate injuries due to slips, trips and falls |
| 11 | Heat and thermal stress | Appropriate ventilation, hydration, rest breaks and cooling equipment will be provided  
Dial 911 when necessary | Reduce heat stroke, heat stress and cold stress related injuries |
| 12 | Prevention through design | Design will be incorporated to eliminate or minimize hazards (e.g., material selection, access to equipment for installation and maintenance, placement of equipment, duct work and condensate lines) | Reduce worker injuries and exposure to toxic substances and physical hazards |

14 29 CFR 1926 Subpart M - Fall Protection  
15 29 CFR 1926 Subpart C - General Safety and Health Provisions  
16 29 CFR 1926 Subpart C - General Safety and Health Provisions
Forced Air

Design:
  2) Load Calculation and Equipment Selection
  3) Ductwork and Termination Design

Equipment Installation:
  4) Preparation for New Equipment
  5) Fuel Delivery System for Fuel Oil
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  17) Air Flow
  18) Electrical Service
  19) Refrigerant Line Inspection
  20) Sequence of Operation
  21) Occupant Education
  22) Evaporative Cooler Maintenance and Repairs
  23) Regional Considerations
### Topic: Forced Air
**Subtopic:** Design

2) **Detail Name:** Load Calculation and Equipment Selection

#### Desired Outcome:
- Equipment sized properly and operates efficiently

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Load calculation: Heat loss or gain[^17]</td>
<td>Heat loss or gain of the house will be calculated considering the following:</td>
<td>Accurately calculate sensible and latent load for the house</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• R-Values of building components</td>
<td>Properly size equipment for load</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• U-Value and Solar Heat Gain Coefficient (SHGC) of glazing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Orientation and exterior shading of glazing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Duct heat loss or gain</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Infiltration</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ventilation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Internal gains</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Room-by-room calculations will be performed when installing new duct systems or in retro-commission projects</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Load calculation: Design conditions for single-stage or single-speed equipment[^18]</td>
<td>Interior design conditions will be selected based on occupant preferences and lifestyle</td>
<td></td>
</tr>
</tbody>
</table>

[^17]: ANSI/ASHRAE Standard 90.2-2007
[^18]: ANSI/ASHRAE Standard 90.2-2007
|   | Exterior design conditions will be appropriate for regional weather conditions  
In all cases of dry climates, the cooling design temperature will be set to the mean extreme temperature  
In all cases of humid climates, the cooling design temperature will be set to less than 1% |  
|---|---|
| 3 | Load calculation: Design conditions for multi-stage, variable-speed equipment 19  
Interior design conditions will be selected based on occupant preferences and lifestyle  
Exterior design conditions will be appropriate for regional weather conditions  
In all cases of dry climates, the cooling design temperature will be set to the mean extreme temperature  
In all cases of humid climates, the cooling design temperature will be set to less than 1% |  
|   | Accurately calculate sensible and latent load for the house  
Properly size equipment for load |  
| 4 | Equipment selection: Air conditioning and heat pumps in humid climates 20  
Equipment capable of meeting the sensible and latent load of the house will be selected using the detailed capacity tables provided by the manufacturer  
Equipment will not be sized by more than 115% of total load or next available size |  
|   | Ensure equipment is able to heat, cool and dehumidify the house |

19 ANSI/ASHRAE Standard 90.2-2007  
20 ANSI/ASHRAE Standard 90.2-2007
| 5 | **Equipment selection:** Heat pumps | In heating dominated climates and where need for summer dehumidification is minimal, equipment will be selected to provide a balance point near 30°

Use the lowest capacity cooling equipment required to cool the house

Balance point will be calculated using the detailed capacity tables provided by the manufacturer | Maximize heating potential of the compressor |
|---|---|---|---|
| 6 | **Equipment selection:** Furnaces with air conditioning | The smallest capacity heating equipment will be selected that is capable of meeting the heating load and providing the air movement required by the air conditioning

The lowest capacity cooling equipment required to cool the house will be used | Equipment meets the heating load of the house

Equipment moves required air for air conditioning |
| 7 | **Equipment selection:** Furnaces only (no air conditioning) | The smallest capacity heating equipment will be selected that is capable of meeting the heating load | Equipment meets the heating load of the house |
| 8 | **Equipment selection:** Single-speed, multiple-tap blower | Equipment will be selected that can move desired cooling cubic feet per minute (CFM) at medium speed | Equipment moves required air for air conditioning |

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21 ANSI/ASHRAE Standard 90.2-2007
22 ANSI/ASHRAE Standard 90.2-2007
23 ANSI/ASHRAE Standard 90.2-2007
24 ANSI/ASHRAE Standard 90.2-2007
| 9 | **Equipment selection:** Variable speed blower | Equipment will be selected that can move desired cooling CFM with no greater than 0.8 inches of water column (IWC) external static pressure |

---

25 ANSI/ASHRAE Standard 90.2-2007
**Topic: Forced Air**

**Subtopic:** Design

3) **Detail Name:** Ductwork and Termination Design

**Desired Outcome:**
- Efficient air flow to all rooms ensured by proper ductwork

<table>
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<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sizing</td>
<td>Ducts will be sized using friction charts (^{(26)})</td>
<td>Minimize static pressure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A friction rate of 0.08 inches of water column (IWC) for supplies and 0.06 IWC for returns is recommended.</td>
<td>Maximize air flow</td>
</tr>
<tr>
<td>2</td>
<td>Air handler to return plenum connections</td>
<td>Radius elbow fittings or square fittings with turning vanes will be used to direct return air when a 90° turn is required (^{(27)})</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Air handler to supply plenum</td>
<td>Radius elbow fittings or square fittings with turning vanes will be installed to direct supply air (^{(28)})</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Reducers</td>
<td>Reducers between sections of different size duct will be a minimum of 18&quot; in length</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Supply branch run outs</td>
<td>Runs will be installed as short as possible (^{(29)})</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Boots</th>
<th>If using flexible duct with straight boots, duct will be connected to boot with no bend. A rigid elbow will be used when a flexible duct changes direction.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Supply terminations</td>
<td>Terminations will be selected that are capable of delivering air with proper speed and throw of 80-120% of the farthest wall, floor or ceiling. For stamped metal terminations, opening of boot-to-space connection will be 40% larger than duct cross section.</td>
</tr>
<tr>
<td>8</td>
<td>Return grille sizing</td>
<td>Grille gross area will be equal to or larger than return box. Return box will be bigger than return duct.</td>
</tr>
<tr>
<td>9</td>
<td>Dampers</td>
<td>Dampers will be installed as close to the trunk as possible. Dampers will be adjusted after interior finishes are installed.</td>
</tr>
<tr>
<td>10</td>
<td>Flexible ducts</td>
<td>Flexible ducts will not be bent more than 45° without rigid elbow.</td>
</tr>
<tr>
<td></td>
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<td>---</td>
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</tr>
<tr>
<td>11</td>
<td>Take-offs</td>
<td>Field-fabricated take-offs will not be used. Take-offs that create turbulence will not be used (e.g., elbows with integrated dampers, scoops). Take-offs will be installed onto the trunk according to duct construction standards.</td>
</tr>
<tr>
<td>12</td>
<td>Plenum to trunk connection</td>
<td>The first connection on supply side will be installed with a total equivalent length of less than 45’</td>
</tr>
</tbody>
</table>
**Topic: Forced Air**  
**Subtopic:** Equipment Installation

4) **Detail Name:** Preparation for New Equipment

**Desired Outcome:**
- Existing equipment removed safely and lawfully

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Access                     | A code-compliant walkway and service platform will be installed in attics, if not present  
The walkway and platform will be above the level of insulation  
30 | Ensure new equipment can be installed and serviced |
| 2   | Utility disconnect         | Electricity and fuel will be turned off  
31,32 | Protect workers and occupants from injury |
| 3   | Refrigerant recovery       | Refrigerant will be recovered in accordance with 40CFR 608 (EPA)  
33 | Comply with “Safe Handling of Refrigerant Law”  
Protect workers and occupants from injury |
| 4   | Equipment disconnection    | Refrigerant lines, plumbing, ducts, electric, control wires, vents and fuel supply will be disconnected | Ensure equipment can be removed |

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30 29 CFR 1926 Subpart M - Fall Protection  
32 29 CFR 1926 Subpart K – Electrical  
33 40 CFR 82.154
| 5 | **Removal** | Equipment will be removed (e.g., furnace, air handler, evaporator, condensing unit)  
Equipment will be removed from space without damaging property and disturbing or compressing the insulation  
Equipment will be disposed of lawfully | Provide room to install new equipment and work safely  
Comply with applicable disposal laws |
**Topic: Forced Air**  
**Subtopic: Equipment Installation**

5) **Detail Name:** Fuel Delivery System for Fuel Oil

**Desired Outcome:**
- Fuel oil delivered safely and sufficiently

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Material and support</strong> 34</td>
<td>An approved pipe type in accordance with NFPA will be installed and supported</td>
<td>Prevent corrosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manual oil shut-off valve, union joint and filter fitting will be installed or presence verified</td>
<td>Deliver fuel to system</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ensure material does not sag or leak</td>
</tr>
<tr>
<td>2</td>
<td><strong>Line connections</strong> 35</td>
<td>Approved connectors for line fittings will be used</td>
<td>Install oil lines with no leaks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Approved filter fittings will be used</td>
<td></td>
</tr>
</tbody>
</table>

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34 NFPA 31: Standard for the Installation of Oil-Burning Equipment  
35 NFPA 31: Standard for the Installation of Oil-Burning Equipment
Topic: Forced Air
Subtopic: Equipment Installation

6) **Detail Name:** Fuel Delivery System for Natural Gas and Propane

**Desired Outcome:**
- Natural gas and propane delivered safely and in sufficient amount

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Material and support&lt;sup&gt;36&lt;/sup&gt;</td>
<td>An approved pipe type in accordance with NFPA will be installed and supported</td>
<td>Prevent corrosion&lt;br&gt;Deliver fuel to system&lt;br&gt;Ensure material does not sag or leak</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manual gas shut-off valve, union joint and drip leg will be verified or installed</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Size&lt;sup&gt;37&lt;/sup&gt;</td>
<td>Gas pipes (house main and equipment drops) will be installed for the total connected load of all appliances in accordance with NFPA</td>
<td>Provide sufficient gas flow and pressure to all appliances</td>
</tr>
<tr>
<td>3</td>
<td>Sealant&lt;sup&gt;38&lt;/sup&gt;</td>
<td>Pipes will be sealed with an approved fastening process and sealant according to manufacturer specifications&lt;br&gt;Gas lines will be leak free when tested with an electronic combustible gas leak detector and verified with bubble solution&lt;br&gt;OR&lt;br&gt;Gas lines will be leak free when tested by local codes approved standing pressure test</td>
<td>Install gas lines with no leaks</td>
</tr>
</tbody>
</table>

<sup>36</sup> NFPA 54/ANSI/AGA Z223.1 National Fuel Gas Code<br>
<sup>37</sup> NFPA 54/ANSI/AGA Z223.1 National Fuel Gas Code<br>
<sup>38</sup> NFPA 54/ANSI/AGA Z223.1 National Fuel Gas Code
|   | **Safety devices for propane** | A secondary gas valve safety detector will be installed for propane piping installed below grade 39 | Detect accumulation of dangerous levels of propane in below grade areas |

Topic: Forced Air
Subtopic: Equipment Installation

7) Detail Name: Setting of Air Handler

**Desired Outcome:**
- Air handler set properly in an appropriate place

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Location</td>
<td>Equipment will be installed in a dry location</td>
<td>Prevent rust and corrosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Protect equipment from bulk water and moisture</td>
</tr>
<tr>
<td>2</td>
<td>Clearance 40</td>
<td>Equipment will be installed with proper clearances according to manufacturer</td>
<td>Ensure equipment has proper clearances for fire risk and accessibility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>specifications and local codes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alternative locations will be considered for equipment when existing locations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>are not suitable</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Connections 41</td>
<td>Equipment will be installed so connections allow proper operation of the</td>
<td>Ensure connections do not interfere with operation and service of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>equipment and accessibility (e.g., electrical service, condensate drains,</td>
<td>equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ductwork, fuel, venting, refrigerant lines)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Support: Horizontal air flow, attic</td>
<td>Equipment will be supported with a platform or suspended with threaded rod according to manufacturer specifications and local codes</td>
<td>Ensure equipment is stable, level and does not transmit vibration</td>
</tr>
</tbody>
</table>

40 NFPA 90B
41 NFPA 90B
<table>
<thead>
<tr>
<th></th>
<th>Support: Horizontal air flow, basement or crawl space</th>
<th>Equipment will be supported with a non-wicking, fireproof material or suspended with threaded rod according to manufacturer specifications and local codes</th>
<th>Avoid compressing or disturbing attic insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Support: Up flow on a platform</td>
<td>Equipment will be supported on non-flammable material capable of supporting the weight of the equipment. The air handler opening will be free of obstructions</td>
<td>Properly support equipment Prevent a fire hazard Ensure platform does not impede airflow</td>
</tr>
<tr>
<td>7</td>
<td>Support: Down flow</td>
<td>Equipment will be supported on ductwork capable of supporting the weight of the equipment. Equipment will be supported on ductwork with rigid exterior insulation fastened to the ductwork.</td>
<td>Properly support equipment Protect equipment from moisture damage Reduce heat loss</td>
</tr>
<tr>
<td>8</td>
<td>Sealing</td>
<td>Gaps larger than ¼” between air handler and adjoining ductwork or equipment (e.g., evaporator coil, filter rack) will be bridged with sheet metal. Joints will be sealed with mastic and fiberglass mesh. Joints will be sealed to eliminate all gaps with NFPA 90A and B approved sealant.</td>
<td>Ensure air handler does not leak air Ensure sealing is durable Do not increase resistance to air flow</td>
</tr>
<tr>
<td>9</td>
<td>Drainage: Attics and conditioned space</td>
<td>A secondary drain pan will be installed beneath the equipment with proper pitch and float switch.</td>
<td>Prevent water damage</td>
</tr>
</tbody>
</table>

42 SMACNA HVAC Duct Construction Standard
**Topic:** Forced Air  
**Subtopic:** Equipment Installation

8) **Detail Name:** Duct System

**Desired Outcome:**
- The duct system safely supports peak operation of equipment

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Location: Inside (supply ducts)  
*Duct section located completely within the thermal barrier of the house* | Duct material will be selected with an insulation level and permeability that prevents condensation \(^{43}\) | Prevent condensation on the outside of the ductwork |
| 2   | Location: Outside  
*Duct section located outside of the thermal barrier of the house or in quasi-conditioned spaces* | Duct material will be selected that meets the following criteria:  
- A minimum insulation level of R-8  
- Permeability that prevents condensation  
- Permeability that reduces heat loss or gain from the ductwork \(^{44}\) | Prevent condensation on the outside of the ductwork  
Reduce thermal loss or gain from the ductwork |
| 3   | Fire rating | Ducts will be installed in accordance with the fire rating of local codes \(^{45}\) | Prevent a fire hazard |
| 4   | Support \(^{46}\) | Ductwork will be supported in a manner that does not constrict ductwork or duct insulation per SMACNA duct construction standards, ADC for flexible duct or NAIMA for | Ensure ducts do not sag, bend, trap water or experience diminished air flow |

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\(^{43}\) SMACNA HVAC Duct Construction Standard  
\(^{44}\) SMACNA HVAC Duct Construction Standard  
\(^{45}\) SMACNA HVAC Duct Construction Standard  
\(^{46}\) SMACNA HVAC Duct Construction Standard
<table>
<thead>
<tr>
<th></th>
<th>fiberglass duct</th>
<th>fiberglas duct</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td><strong>Protection</strong></td>
<td>Protect equipment from damage</td>
</tr>
<tr>
<td></td>
<td>Ducts will be routed such that service and repair to the house and its systems does not damage the ducts</td>
<td>Ensure equipment operates as designed</td>
</tr>
<tr>
<td>6</td>
<td><strong>Fastening:</strong> Metal to flexible duct</td>
<td>Ensure duct connections are durable</td>
</tr>
<tr>
<td></td>
<td>Flexible duct-to-metal connections will be fastened with tie bands using a tie band tensioning tool</td>
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<tr>
<td></td>
<td>Beaded collars will be installed for all sheet metal to flexible duct connections</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturer specifications will be followed</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><strong>Fastening:</strong> Metal to metal</td>
<td>Ensure duct connections are durable</td>
</tr>
<tr>
<td></td>
<td>Metal-to-metal connections will be fastened with mechanical fasteners</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gaps larger than ¼” will be bridged with sheet metal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Joints will be sealed with mastic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Joints smaller than ¼” will be sealed with NFPA 90A and B approved sealant</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><strong>Fastening:</strong> Duct board to metal</td>
<td>Ensure duct connections are durable</td>
</tr>
<tr>
<td></td>
<td>Duct board to metal connections will be fastened with mechanical fasteners</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Joints and connections will be sealed with UL 181A listed tapes or mastics</td>
<td></td>
</tr>
</tbody>
</table>

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47 SMACNA HVAC Duct Construction Standard

48 SMACNA HVAC Duct Construction Standard
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
</table>
| 9 | **Fastening:** Boot to house connection | **Boots will be fastened to the house with mechanical fasteners**  
Connection will be sealed with mastic, caulk or gaskets  
Ensure duct connections are durable |
| 10 | **Terminations** | **Terminations capable of delivering air with proper speed and throw of 80-120% of the farthest wall, floor or ceiling will be selected**  
Deliver and properly mix air in the house |
| 11 | **Filtration** | **Filter bypasses will be eliminated**  
Filters will be changed  
Protect equipment from dirt and debris |
| 12 | **External static pressure** | **Ductwork, filter and other equipment will be installed so that total external static pressure does not exceed manufacturer specifications**  
Ensure equipment operates as designed |
| 13 | **Air flow:** Cooling and heat pump systems | **Measured air flow per ton will be within 15% of manufacturer specifications**  
Air flow will be measured in accordance with following standards: ASHRAE, ANSI ACCA QI 5 2007, TABB and NEBB |
| 14 | **Temperature rise:** Heating only systems | **Temperature rise will be measured and result will be in accordance with manufacturer specifications** |

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49 SMACNA HVAC Duct Construction Standard  
50 SMACNA HVAC Duct Construction Standard  
51 SMACNA HVAC Duct Construction Standard
<p>| | | |</p>
<table>
<thead>
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<th></th>
<th></th>
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</tr>
</thead>
</table>
| 15 | **System protection during construction and renovation** | Registers, grilles and diffusers will be blocked, masked or otherwise sealed with a durable material  
Use of system will not be allowed during renovation or construction  
Contractor and occupant will be educated on necessity of protecting equipment | Protect equipment and occupants from debris in system |
| 16 | **Room pressure balancing** | An appropriate means of pressure balancing will be installed (e.g., transfer grilles, jumper ducts, individual room returns)  
No room will exceed +/- 3 Pascals with reference to the outside with all interior doors closed and the air handler running | Ensure system has unrestricted flow of air between supplies and returns  
Minimize infiltration and exfiltration caused by system  
Do not interfere with safe operation of combustion appliances |
| 17 | **Sealing: New ductwork** | Total system leakage (including air handler) will not exceed 100 cubic feet per minute (CFM) at 25 Pascals  
*(for partial duct system replacement or improvement, existing ductwork specification will be applied)* | Minimize system air leakage |
| 18 | **Sealing: Existing ductwork** | Accessible joints, cracks, seams, holes and penetrations will be sealed |  
52 SMACNA HVAC Duct Construction Standard  
53 SMACNA HVAC Duct Construction Standard |
Topic: Forced Air  
Subtopic: Equipment Installation  

9) **Detail Name:** Heating and Cooling Controls

**Desired Outcome:**
- Heating and cooling controls installed and set properly

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Removal of mercury-based thermostats</td>
<td>Mercury-based thermostat will be removed safely and in accordance with EPA regulations 54</td>
<td>Protect workers and occupants from injury</td>
</tr>
<tr>
<td>2</td>
<td>Removal of existing controls</td>
<td>Existing controls will be removed in accordance with lead safe work rules EPA 55</td>
<td>Protect environment from damage</td>
</tr>
<tr>
<td>3</td>
<td>Penetrations</td>
<td>Penetrations for control wiring will be sealed with a durable sealant (e.g., caulk, silicone, foam) 56</td>
<td>Ensure controls operate as designed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Minimize infiltration and exfiltration from house</td>
</tr>
<tr>
<td>4</td>
<td>Thermostat location</td>
<td>Thermostats will be installed to reflect the temperature of the zone in which they are installed</td>
<td>Ensure controls operate as designed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thermostats will not be exposed to extreme temperatures, radiant heat sources and drafts</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Blower speed</td>
<td>Blower speed will be set for equipment according to manufacturer specifications</td>
<td>Ensure equipment has correct air flow</td>
</tr>
</tbody>
</table>

54 40 CFR 271.13  
55 OSHA 3142-09R  
56 ASTM C1193 - 09
<table>
<thead>
<tr>
<th></th>
<th><strong>Thermostat Selection:</strong> Heat pump</th>
<th>A thermostat with equipment supplementary heat lock out that can interface with an outside temperature sensor will be selected</th>
</tr>
</thead>
</table>
| 7 | **Heat Pump: Supplementary heat**  | Supplementary heat will be used on heat pumps with conditions allowing for a balance point of less than 30°  
Supplementary heat lock out will be set to 35° outside temperature or dual-fuel or hybrid change-over temperature to 38° outside temperature | Maximize heating output of compressor (heat pump mode-eliminates supplementary heat) to achieve energy efficiency |
<p>| 8 | <strong>Heat Pump: Low ambient compressor lock out</strong> | Low ambient compressor lock out will be set to 0° outside temperature or ambient compressor lock out will be disabled |
| 9 | <strong>Heat Pump: Outside temperature sensor</strong> | An outside temperature sensor will be installed according to manufacturer specifications | Ensure equipment operates as designed |
| 10 | <strong>Heat Pump: Supplementary heat wiring</strong> | Supplementary heat will be wired onto second stage heating terminal (W2) | Supplementary heat cannot operate in stage-one heating |
| 11 | <strong>Thermostat: Installer programming</strong> | The installer options will be set to match the thermostat to the equipment and control board settings | Ensure equipment operates as designed |
| 12 | <strong>Time delay settings</strong> | Time delay for equipment will be set according to manufacturer specifications and as appropriate for the climate zone (e.g., no time delay for hot-humid climates) | Maximize transfer of heat without adversely affecting inside humidity levels |</p>
<table>
<thead>
<tr>
<th></th>
<th>Humidistat: Location</th>
<th>Humidistat will be installed to reflect humidity of the zone in which it is installed. Humidistat will be installed in a dry location</th>
<th>Ensure controls operate as designed</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Occupant education</td>
<td>Occupants will be educated on proper use of thermostat including: • Proper use of setbacks for air conditioners and heat pumps • Allowing occupant comfort to determine setback for combustion heating appliances • Using emergency heat appropriately</td>
<td>Ensure equipment and controls operate as designed Provide comfort throughout house</td>
</tr>
</tbody>
</table>
Topic: Forced Air  
Subtopic: Equipment Installation

10) **Detail Name:** Venting System

**Desired Outcome:**
- Combustion products properly vented to the outside

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Combustion air</td>
<td>Combustion air inlet will be in compliance with NFPA 58</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Installation</td>
<td>Venting systems will be installed considering proper material, pitch, proper common venting, chimney liner, clearance, total equivalent length and termination according to NFPA 54, 31, 211 and Category I, III, IV 59</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Category I venting systems will be installed according to (NFPA 54/ANSI z223.1)</td>
<td>Exhaust combustion products to the outside</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Category III and IV venting systems will be installed according to the manufacturer’s installation instructions</td>
<td>Do not damage the house</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Protect workers and occupants from injury</td>
</tr>
<tr>
<td>3</td>
<td>Orphaned equipment</td>
<td>Existing vent system or chimney will be resized or relined according to the NFPA when one or more common-vented appliances are removed 60</td>
<td></td>
</tr>
</tbody>
</table>

58 NFPA 31 or NFPA 54/ANSI/AGA Z223.1  
59 NFPA 31 or NFPA 54/ANSI/AGA Z223.1  
60 NFPA 31 or NFPA 54/ANSI/AGA Z223.1
**Topic: Forced Air**

**Subtopic: Equipment Installation**

11) **Detail Name:** Condensate Drainage of Heating and Air Conditioning Equipment

**Desired Outcome:**
- Equipment and condensate drain operate as designed

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connection</td>
<td>Connections in condensate drain system will be water tight</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Insulation</td>
<td>Condensate drain lines will be insulated when there is potential for condensation or freezing on the drain line</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Overflow protection: Upflow</td>
<td>Secondary drain pan and float switch will be installed when overflow could damage finished surfaces OR Float switch in the primary condensate drain for upflow systems will be installed when overflow could damage finished surfaces</td>
<td>Ensure condensate drain connections do not leak</td>
</tr>
<tr>
<td>4</td>
<td>Pumps</td>
<td>Condensate drain pumps will be installed when condensate cannot be drained by gravity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power source for pump will be installed</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Operation and drainage of pump will be verified</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Vents and traps</td>
<td>Vents and traps will be installed on condensate drain lines, including condensing heating systems</td>
<td>Ensure condensate drain operates as designed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vent will be located after the</td>
<td>Ensure condensate drain does not leak air</td>
</tr>
<tr>
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<td>---</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>trap</td>
<td>For combustion heating equipment, use the trap supplied with the equipment and follow manufacturer installation instructions</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Drain pan</td>
<td>A secondary drain pan will be installed for all attic air conditioning, air handler or evaporator coil installations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prevent water damage from drain system malfunction</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Float switch</td>
<td>All secondary drain pans will have a float switch and be drained away through a drain hose</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prevent water overflowing the pan and draining onto the ceiling below</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Termination</td>
<td>Condensate drain will be terminated in accordance with authority having jurisdiction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Condensate does not leak to the house</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Condensate drain does not freeze</td>
<td></td>
</tr>
</tbody>
</table>
### Topic: Forced Air
**Subtopic:** Equipment Installation

#### 12) Detail Name: Regional Considerations

<table>
<thead>
<tr>
<th>Row</th>
<th>Region</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very Cold</td>
<td>New systems will be installed inside of the conditioned space of the house</td>
<td>Ensure efficient system operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The house, as well as individual rooms, will remain at either a balanced or</td>
<td>Avoid moisture-related damage to the house</td>
</tr>
<tr>
<td></td>
<td></td>
<td>negative pressure of no greater than 3 Pascals with reference to the outside</td>
<td>Ensure occupant safety by properly venting combustion gasses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Combustion inlets will be terminated above snow line and protected from snow</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>cover</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Cold</td>
<td>Combustion inlets will be terminated above snow line and protected from snow</td>
<td>Ensure occupant safety by properly venting combustion gasses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cover</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Mixed Humid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Hot Humid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Marine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Hot Dry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Topic: Forced Air**  
**Subtopic:** Commissioning of Equipment

**13) Detail Name:** Leak Detection

**Desired Outcome:**
- Dangerous leaks detected before causing injury or damage

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carbon monoxide (CO) detection</td>
<td>Personal CO detector will be worn, in accordance with Building Performance Institute (BPI) standards</td>
<td>Worker and occupants are protected from possible CO poisoning</td>
</tr>
<tr>
<td>2</td>
<td>Gas leak detection</td>
<td>Gas pipes will be tested for leaks with an electronic combustible gas leak detector and verified with bubble solution OR A code-approved standing pressure test will be conducted to detect leaks 61</td>
<td>Ensure gas lines do not leak</td>
</tr>
<tr>
<td>3</td>
<td>Fuel oil leak detection</td>
<td>Oil tank, piping and equipment will be visually inspected for oil leaks 62</td>
<td>Ensure fuel oil lines do not leak</td>
</tr>
<tr>
<td>4</td>
<td>Electricity</td>
<td>Electrical service will be inspected for proper wiring size, overcurrent protection and service disconnect 63</td>
<td>Ensure electric lines do not overheat, melt or short</td>
</tr>
</tbody>
</table>
**Topic: Forced Air**

**Subtopic:** Commissioning of Equipment

14) **Detail Name:** Data Plate Verification

**Desired Outcome:**
- Data recorded for commissioning and future service work is recorded

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Data plate verification</td>
<td>Equipment will be visually inspected</td>
<td>Ensure technician has equipment data necessary for commissioning and future service work</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Information will be recorded on the equipment data plates inside and outside</td>
<td></td>
</tr>
</tbody>
</table>
**Topic: Forced Air**  
**Subtopic: Commissioning of Equipment**

15) **Detail Name:** Venting System

**Desired Outcome:**
- Combustion byproducts properly vented to the outside

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Combustion air</td>
<td>Combustion air inlet will be in compliance with NFPA 64</td>
<td>Exhaust combustion products to the outside</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Protect house from damage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Protect workers and occupants from injury</td>
</tr>
<tr>
<td>2</td>
<td>Visual inspection</td>
<td>Venting system will be inspected according to NFPA (e.g., damage, deterioration, proper material, pitch, common venting, chimney liner, clearance, total equivalent length and termination) 65</td>
<td>Category I venting systems will be inspected to assure compliance with NFPA 54/ANSI z223.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Category III and IV venting systems will be inspected to ensure compliance with manufacturer installation instructions</td>
</tr>
<tr>
<td>3</td>
<td>Orphaned equipment</td>
<td>Orphaned combustion appliance venting systems will be inspected for compliance with NFPA 66</td>
<td></td>
</tr>
</tbody>
</table>

64 NFPA 31 or NFPA 54/ANSI/AGA Z223.1  
65 NFPA 31 or NFPA 54/ANSI/AGA Z223.1  
66 NFPA 31 or NFPA 54/ANSI/AGA Z223.1
**Topic: Forced Air**  
**Subtopic:** Commissioning of Equipment

16) **Detail Name:** Combustion Analysis

**Desired Outcome:**
- Analysis on critical components and operations completed to industry and manufacturer specifications

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oil system: Nozzle size</td>
<td>Nozzle size will be correct for design input and within equipment firing rate of nozzle manufacturer.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Fuel pressure</td>
<td>Measurement will be verified according to manufacturer specifications.</td>
<td>Ensure equipment operates as designed.</td>
</tr>
<tr>
<td>3</td>
<td>Oil system: Steady state efficiency (SSE)</td>
<td></td>
<td>Ensure equipment operates safely.</td>
</tr>
<tr>
<td>4</td>
<td>Oil system: Smoke test</td>
<td>Smoke spot reading will be in accordance with burner manufacturer specifications.</td>
<td>Ensure equipment operates efficiently.</td>
</tr>
<tr>
<td>5</td>
<td>Net stack temperature</td>
<td>Net stack temperature will be measured and verified according to manufacturer specifications.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carbon dioxide and oxygen</td>
<td>Measurement will be verified according to industry manuals (e.g., Testo, Bacharach)</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Excess air</td>
<td>Excess air will be calculated and shown to be in accordance with industry manuals (e.g., Testo, Bacharach)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Carbon monoxide (CO) in flue gas</td>
<td>CO in the undiluted flue gas will be less than level specified in ANSI Z21.1</td>
<td></td>
</tr>
</tbody>
</table>
### Topic: Forced Air

**Subtopic:** Commissioning of Equipment

#### 17) Detail Name: Air Flow

**Desired Outcome:**
- Air flow is properly tested

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total air flow</td>
<td>Total system air flow will be measured by:</td>
<td>Ensure equipment operates as designed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Temperature rise</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Flow plate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Fan depressurization device (e.g., Duct Blaster)</td>
<td>Ensure equipment operates efficiently</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ensure equipment provides comfort</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ensure equipment operates safely</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ensure equipment is durable</td>
</tr>
<tr>
<td>2</td>
<td>External static pressure</td>
<td>External static pressure will be in accordance with manufacturer specifications</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Pressure drop: Coil</td>
<td>Pressure drop across cooling coils will be in accordance with manufacturer specifications</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Pressure drop: Filter</td>
<td>Pressure drop across filter will be in accordance with manufacturer specifications</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Balancing room flow: New ductwork</td>
<td>Air flow will be measured at each register to ensure proper air flow delivery</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Supply wet bulb and dry bulb</td>
<td>Supply wet bulb and dry bulb air temperatures will be recorded</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Return wet bulb and dry bulb</td>
<td>Return wet bulb and dry bulb air temperatures will be recorded</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----------------------------</td>
<td>---------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Temperature rise: Gas and oil furnaces only</td>
<td>Temperature rise between the supply and return will be in accordance with manufacturer specifications</td>
<td></td>
</tr>
</tbody>
</table>
**Topic: Forced Air**  
*Subtopic: Commissioning of Equipment*

18) **Detail Name:** Electrical Service

**Desired Outcome:**
- Electrical components properly tested

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Polarity</td>
<td>Polarity of equipment will be correct 73</td>
<td>Ensure equipment operates as designed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ensure equipment operates safely</td>
</tr>
<tr>
<td>2</td>
<td>Voltage: Incoming power</td>
<td>Voltage will be in accordance with manufacturer specifications 74</td>
<td>Ensure equipment operates as designed</td>
</tr>
<tr>
<td>3</td>
<td>Voltage: Contactor</td>
<td>Voltage drop will be within acceptable range according to manufacturer specifications 75</td>
<td>Ensure contactor does not overheat</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ensure equipment operates as designed</td>
</tr>
<tr>
<td>4</td>
<td>Grounding</td>
<td>Adequate grounding will be present 76</td>
<td>Ensure equipment operates as designed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ensure equipment operates safely</td>
</tr>
<tr>
<td>5</td>
<td>Blower amperage</td>
<td>Amperage will not exceed manufacturer full load amperage 77</td>
<td>Ensure equipment operates as designed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ensure equipment operates efficiently</td>
</tr>
<tr>
<td>6</td>
<td>Compressor amperage</td>
<td>Amperage will not exceed manufacturer full load amperage 78</td>
<td>Ensure equipment operates as designed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ensure equipment operates safely</td>
</tr>
</tbody>
</table>

73 NFPA 70A  
74 NFPA 70A  
75 NFPA 70A  
76 NFPA 70A  
77 NFPA 70A  
78 NFPA 70A
<table>
<thead>
<tr>
<th></th>
<th>Door switch operation</th>
<th>Blower compartment safety switch operation will be verified</th>
<th>Ensure blower does not operate during service</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Heat pump: Emergency heat</td>
<td>Emergency heat circuit functions will be verified</td>
<td>System delivers heat in case of compressor failure</td>
</tr>
</tbody>
</table>
**Topic: Forced Air**  
**Subtopic:** Commissioning of Equipment

19) **Detail Name:** Refrigerant Line Inspection

**Desired Outcome:**  
- Refrigerant lines properly installed

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Insulation</td>
<td>All refrigerant lines will be insulated when installed in high temperature areas (e.g., attic, roofs)</td>
<td>Ensure refrigerant lines do not gain excessive heat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suction lines will be insulated</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Ultraviolet (UV) protection of insulation</td>
<td>If exposed to sunlight, refrigerant line insulation will be protected from UV degradation</td>
<td>Install insulation so it does not degrade</td>
</tr>
<tr>
<td>3</td>
<td>Sizing</td>
<td>Refrigerant lines will be sized to meet manufacturer specifications for the installed equipment</td>
<td>Ensure system moves appropriate volume of refrigerant</td>
</tr>
<tr>
<td>4</td>
<td>Installation quality</td>
<td>Refrigerant lines will be installed without kinks, crimps or excessive bends</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Support</td>
<td>Refrigerant lines will be routed, supported and secured to house in a manner that protects the line from damage by workers or occupants</td>
<td>Ensure refrigerant lines do not move, vibrate or sag</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Protect lines from damage</td>
</tr>
</tbody>
</table>
**Topic: Forced Air**

**Subtopic:** Commissioning of Equipment

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### 20) Detail Name: Sequence of Operation

**Desired Outcome:**
- Sequence of operation of the system verified

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Verification</td>
<td>The sequence of operation of the system will be verified in accordance with the manufacturer installation, operation and maintenance manual</td>
<td>Ensure system components function and operate in the correct sequence</td>
</tr>
</tbody>
</table>
## Topic: Forced Air

### Subtopic: Commissioning of Equipment

#### 21) Detail Name: Occupant Education

**Desired Outcome:**
- Occupants understand their role and responsibility in the safe, effective and efficient operation of the equipment

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Basic operation</td>
<td>Basic operation of the equipment will be explained (e.g., design conditions, efficiency measures, differences from previous system or situation)</td>
<td>Ensure occupant has a reasonable expectation of the capability the of equipment</td>
</tr>
<tr>
<td>2</td>
<td>System controls (e.g., thermostat, humidistat)</td>
<td>Proper operation and programming of system controls to achieve temperature and humidity control will be explained</td>
<td>Ensure occupant can operate system controls</td>
</tr>
<tr>
<td>3</td>
<td>System disconnects</td>
<td>Inside and outside electrical disconnects and fuel shut-offs will be demonstrated</td>
<td>Ensure occupant can shut off equipment in emergencies</td>
</tr>
<tr>
<td>4</td>
<td>Combustion air inlets</td>
<td>Location of combustion air inlets will be identified for occupant</td>
<td>Ensure occupant does not block combustion air inlets</td>
</tr>
<tr>
<td>5</td>
<td>Blocking air flow</td>
<td>Proper placement of interior furnishings with respect to registers will be explained</td>
<td>Ensure occupant does not prevent equipment from operating as designed</td>
</tr>
</tbody>
</table>

79 ANSI/ASHRAE Standard 62.2-2010  
80 ANSI/ASHRAE Standard 62.2-2010  
81 ANSI/ASHRAE Standard 62.2-2010  
82 ANSI/ASHRAE Standard 62.2-2010  
83 ANSI/ASHRAE Standard 62.2-2010  
84 ANSI/ASHRAE Standard 62.2-2010
<table>
<thead>
<tr>
<th>6</th>
<th><strong>Routine maintenance</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>explained</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Importance of leaving interior doors open as much as possible will be explained</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Proper filter selection and how to change filter will be explained</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Importance of keeping outside unit clear of debris, vegetation, decks and other blockage will be explained</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Importance and timing of routine professional maintenance will be explained</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Ensure equipment operates as designed</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7</th>
<th><strong>Calling heating, ventilation and air conditioning (HVAC) contractor</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Situations when the occupant should contact the HVAC contractor will be explained, including:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Fuel odors</td>
</tr>
<tr>
<td></td>
<td>• Water draining from secondary drain line</td>
</tr>
<tr>
<td></td>
<td>• Emergency heat indicator always on for a heat pump system</td>
</tr>
<tr>
<td></td>
<td>• System blowing cold air during heating season and vice versa</td>
</tr>
<tr>
<td></td>
<td>• Icing of the evaporator coil during cooling mode</td>
</tr>
<tr>
<td></td>
<td>• Outside unit never defrosts</td>
</tr>
<tr>
<td></td>
<td>• Unusual noises</td>
</tr>
<tr>
<td></td>
<td><strong>Occupant contacts installer when system is not operating as designed</strong></td>
</tr>
</tbody>
</table>

---

85 ANSI/ASHRAE Standard 62.2-2010  
86 ANSI/ASHRAE Standard 62.2-2010
<table>
<thead>
<tr>
<th></th>
<th>Unusual odors</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Carbon monoxide (CO)</td>
</tr>
<tr>
<td></td>
<td>A CO detector will be installed</td>
</tr>
<tr>
<td></td>
<td>Protect occupants from injury</td>
</tr>
<tr>
<td>9</td>
<td>Warranty and service</td>
</tr>
<tr>
<td></td>
<td>Occupant will be provided with relevant manuals and warranties</td>
</tr>
<tr>
<td></td>
<td>Provide manuals and warranties for future servicing</td>
</tr>
</tbody>
</table>

87 ANSI/ASHRAE Standard 62.2-2010
### Topic: Forced Air

**Subtopic:** Commissioning of Equipment

#### 22) Detail Name: Evaporative Cooler Maintenance and Repairs

**Desired Outcome:**
- Evaporative cooler evaluated and maintained as needed

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Assessment and diagnosis</td>
<td>The following system elements will be assessed:</td>
<td>Ensure all components function properly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pump</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pan</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Spider</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Float</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Damper</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Roof jack, support</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Water line</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Water valve</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Electrical</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pads</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Motor</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fan</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elements will be repaired or replaced as needed</td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
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</tr>
<tr>
<td>---</td>
<td>----------------------</td>
<td>----------------------------------------------------------------</td>
<td>----------------------------------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td><strong>Repair and maintenance</strong></td>
<td>Calcium deposits will be removed</td>
<td>Ensure evaporative cooler functions properly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pads will be replaced</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Any additional repairs or replacements will be made as necessary</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>Occupant education</strong></td>
<td>A regular service schedule will be recommended to occupant</td>
<td>Ensure the occupant understands the importance of regular maintenance and basic operation</td>
</tr>
<tr>
<td></td>
<td>88</td>
<td>Issues regarding multiple systems running will be discussed with occupant</td>
<td></td>
</tr>
</tbody>
</table>

88 ANSI/ASHRAE Standard 62.2-2010
## Topic: Forced Air

**Subtopic:** Commissioning of Equipment

### 23) Detail Name: Regional Considerations

<table>
<thead>
<tr>
<th>Row</th>
<th>Region</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very Cold</td>
<td>Condensate line will be insulated</td>
<td>Avoid freezing</td>
</tr>
<tr>
<td>2</td>
<td>Cold</td>
<td>Condensate line will be insulated</td>
<td>Avoid freezing</td>
</tr>
<tr>
<td>3</td>
<td>Mixed Humid</td>
<td>Refrigerant will be weighed into heating, ventilation and air conditioning (HVAC) systems when outside temperatures do not facilitate accurate testing of system charge. Heating and cooling refrigerant lines will be insulated.</td>
<td>Ensure proper equipment operation. Avoid energy loss and condensation.</td>
</tr>
<tr>
<td>4</td>
<td>Hot Humid</td>
<td>Refrigerant will be weighed into heating, ventilation and air conditioning (HVAC) systems when outside temperatures do not facilitate accurate testing of system charge.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Marine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Hot Dry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Ducts**

**Duct Sealing:**
- 24) Preparation and Mechanical Fastening
- 25) Support
- 26) Sealing System
- 27) Proprietary Spray Application
- 28) Sealing System Components
- 29) Return – Framed Platform
- 30) Dual Cooling Up Ducts
- 31) Removing Supply Vents From Garages

**Duct Insulation:**
- 32) Insulating Flex Ducts
- 33) Insulating Metal Ducts
# Topic: Ducts

**Subtopic:** Duct Sealing

## 24) Detail Name: Preparation and Mechanical Fastening

**Desired Outcome:**
- Ducts and plenums properly fastened to prevent leakage

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Preparation</td>
<td>Surrounding insulation will be cleared to expose joints being sealed</td>
<td>Gain access while maintaining insulation value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duct surface to accept sealant will be cleaned</td>
<td>Achieve proper adhesion for airtight seal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation will be returned or replaced with equivalent R-value</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Metal to metal</td>
<td>Ducts will be fastened with a minimum of three equally spaced screws</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Flex to metal</td>
<td>Joints will be fastened with tie bands using a tie band tensioning tool</td>
<td>Ensure durable joints</td>
</tr>
<tr>
<td>4</td>
<td>Duct board to duct board</td>
<td>Joints will be fastened with clinch stapler</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Duct board to flexible duct</td>
<td>Metal take-off collar will be used</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Metal plenum to air handler cabinet</td>
<td>Plenum will be fastened with a minimum of three equally spaced screws</td>
<td></td>
</tr>
</tbody>
</table>

---

89 SMACNA HVAC Duct Construction Standard  
90 SMACNA HVAC Duct Construction Standard  
91 SMACNA HVAC Duct Construction Standard  
92 SMACNA HVAC Duct Construction Standard  
93 SMACNA HVAC Duct Construction Standard  
94 SMACNA HVAC Duct Construction Standard
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Duct board plenum to air handler cabinet</td>
<td>Termination bar or metal strip will be fastened with screws. Duct board will be installed between the screw and the termination bar.</td>
</tr>
<tr>
<td>8</td>
<td>Boot to wood</td>
<td>Screws or nails will be used to fasten boot to wood.</td>
</tr>
<tr>
<td>9</td>
<td>Boot to gypsum</td>
<td>Boot hanger will be fastened to adjacent framing with screws or nails. Boot will be connected to boot hanger with screws. Integral snap boots will be installed.</td>
</tr>
<tr>
<td>10</td>
<td>Duct board to flex</td>
<td>Metal take-off collar will be used.</td>
</tr>
</tbody>
</table>

---

95 SMACNA HVAC Duct Construction Standard
96 SMACNA HVAC Duct Construction Standard
97 SMACNA HVAC Duct Construction Standard
Topic: Ducts
Subtopic: Duct Sealing

25) Detail Name: Support

Desired Outcome:
- Ducts and plenums properly supported

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Support (applies to all duct types)</td>
<td>Flexible and duct board ducts and plenums will be supported every 4’ using min 1 ½” wide material. Support materials will be applied in a way that does not crimp duct work or cause the interior dimensions of the duct work to be less than specified (e.g., ceiling, framing, strapping). Metal ducts will be supported by metal strapping, rods or other materials per standards.</td>
<td>Eliminate falling and sagging</td>
</tr>
</tbody>
</table>
**Topic: Ducts**
**Subtopic:** Duct Sealing

**26) Detail Name:** Air Sealing System

**Desired Outcome:**
- Ducts and plenums sealed to prevent leakage

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>New component to new component sealant selection</td>
<td>Any closure system used will meet or exceed applicable standards</td>
<td>Provide air sealing effectiveness of adhesive may be achieved with new components</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seams, cracks, joints, holes and penetrations less than ¼” will be sealed using fiberglass mesh and mastic</td>
<td>Eliminate air leakage into or out of ducts and plenums</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mastic alone will be acceptable for holes less than ¼” that are more than 10’ from air handler</td>
<td>Ensure adhesion of primary air seal (fiberglass mesh and mastic) to the duct</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seams, cracks, joints, holes and penetrations between ¼” and ¾” will be sealed in two stages:</td>
<td>Reinforce air seal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• They will be backed using temporary tape (e.g., duct tape) as a support prior to sealing</td>
<td>Support mastic and fiberglass mesh during curing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• They will be sealed using fiberglass mesh and mastic</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>New component to existing component</td>
<td>Fiberglass mesh and mastic will overlap temporary tape by at least 1” on all sides</td>
<td>Eliminate air leakage into or out of ducts and plenums</td>
</tr>
<tr>
<td>3</td>
<td>Existing component to existing component</td>
<td>Fiberglass mesh and mastic will overlap temporary tape by at least 1” on all sides</td>
<td></td>
</tr>
</tbody>
</table>

99 SMACNA HVAC Duct Construction Standard
100 SMACNA HVAC Duct Construction Standard
101 SMACNA HVAC Duct Construction Standard
| The fiberglass mesh and mastic will become the primary seal |
| Seams, cracks, joints, holes and penetrations larger than ¾” will be repaired using rigid duct material |
| Fiberglass mesh and mastic will overlap repair joint by at least 1” on all sides |
| Fiberglass mesh and mastic will be the primary seal |
| Ensure adhesion of primary air seal (fiberglass mesh and mastic) to the duct |
| Reinforce air seal |
| Support mastic and fiberglass mesh during curing |
**Topic: Ducts**

**Subtopic:** Duct Sealing

---

### 27) Detail Name: Proprietary Spray Application

**Desired Outcome:**
- Ducts and plenums sealed to prevent leakage

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Internal or external application $^{102}$</td>
<td>Installation of sealant will be applied in a way that meets manufacturer specifications as well as UL 181M, NFPA 90A and NFPA 90B</td>
<td>Reduce duct leakage</td>
</tr>
</tbody>
</table>

---

$^{102}$ SMACNA HVAC Duct Construction Standard
**Topic: Ducts**  
**Subtopic:** Duct Sealing

**28) Detail Name:** Air Sealing System Components

**Desired Outcome:**
- Ducts and plenums sealed to prevent leakage

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Duct boot to interior surface&lt;sup&gt;103&lt;/sup&gt;</td>
<td>Gaps between boot and gypsum less than a ¼”, will be air sealed using mastic</td>
<td>Prevent air leakage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gypsum edge will be wetted before applying mastic</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Wooden plenums and building cavities&lt;sup&gt;104&lt;/sup&gt;</td>
<td>Accessible connections and joints will be made air tight using approved material</td>
<td>Ensure ducts and plenums will not leak out of or into return or supply plenums and ducts</td>
</tr>
<tr>
<td>3</td>
<td>Air handler cabinet&lt;sup&gt;105&lt;/sup&gt;</td>
<td>Joints will be closed, cracks and holes not needed for proper function of unit will be sealed using removable sealant (e.g., duct tape)</td>
<td>Reduce air leakage while maintaining accessibility</td>
</tr>
<tr>
<td>4</td>
<td>Filter slot</td>
<td>A pre-manufactured or site manufactured durable filter slot cover will be installed</td>
<td></td>
</tr>
</tbody>
</table>

<sup>103</sup> SMACNA HVAC Duct Construction Standard  
<sup>104</sup> SMACNA HVAC Duct Construction Standard  
<sup>105</sup> SMACNA HVAC Duct Construction Standard
### Topic: Ducts
#### Subtopic: Duct Sealing

#### 29) Detail Name: Return – Framed Platform

**Desired Outcome:**
- The return duct installed to prevent air leakage

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Preparation</td>
<td>Debris and dirt will be cleaned out of the return platform</td>
<td>Allow for the application of rigid materials and sealants</td>
</tr>
<tr>
<td>2</td>
<td>Infill and backing</td>
<td>Backing or infill will be provided as needed to meet the specific characteristics of the selected material and the characteristics of the open space&lt;br&gt;Backin...</td>
<td>Minimize hole size to ensure successful use of sealant&lt;br&gt;Ensure closure is permanent and supports any load (e.g., return air pressure)&lt;br&gt;Ensure sealant does not fall out</td>
</tr>
<tr>
<td>3</td>
<td>Sealant selection 106</td>
<td>Sealants will be compatible with their intended surfaces&lt;br&gt;Sealants will be continuous and meet fire barrier specifications 107</td>
<td>Select permanent sealant&lt;br&gt;Ensure sealant meets or exceeds the performance characteristics of the surrounding materials</td>
</tr>
</tbody>
</table>

---

106 SMACNA HVAC Duct Construction Standard
107 ASTM C834 - 10
**Topic: Ducts**

**Subtopic: Duct Sealing**

**30) Detail Name:** Dual Cooling Up Ducts

- **Desired Outcome:** Up ducts sealed to prevent pressurization leakage

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Backing and infill | Backing or infill will be provided as needed to meet the specific characteristics of the selected material and the characteristics of the up duct opening  
A material will be rated for use in duct systems  
The infill will not bend, sag or move once installed | Minimize hole size to ensure successful use of sealant  
Ensure closure is permanent and supports any pressure produced by wind or air handler fan  
Ensure sealant does not fall out |
| 2   | Sealant selection  | Sealants will be compatible with their intended surfaces  
Sealants will be continuous and meet class 1 specifications<sup>108</sup>                                                                 | Select permanent sealant  
Ensure sealant meets or exceeds the performance characteristics of the surrounding materials |
### Topic: Ducts
#### Subtopic: Duct Sealing

**31) Detail Name:** Removing Supply Vents From Garages

- **Desired Outcome:** Safe removal of supply garage vents

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | **Removal of supply run feeding vent in garage** | Supply run feeding the register will be truncated nearest the supply plenum as possible  
If directly connected to the plenum, it will be truncated at the plenum  
If connected to a Y or T branch system it will be truncated at the Y or T | Minimize surface area of duct |
| 2   | **Patching of the hole in the duct system created by removal** | All holes in sheet metal ducts will be patched with sheet metal and secured with sufficient screws to hold the patch flat without gaps  
Holes left in any Y or T will be capped with sheet metal caps and fastened with at least three screws | Ensure a secure and strong patch |
<p>| 3   | <strong>Sealing of the patch</strong> | All patches will be sealed with mastic meeting UL 181 and in accordance with manufacturer specifications | Ensure an airtight patch |
| 4   | <strong>Removal of discarded ducts</strong> | All abandoned duct work will be removed from work area | Provide a clean work site |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td><strong>Patching of the register hole in garage</strong></td>
<td>Hole created by the removal of the register and boot will be patched and taped using material meeting local fire wall codes</td>
</tr>
<tr>
<td>6</td>
<td><strong>Combustion safety testing requirements</strong></td>
<td>Combustion safety testing will be conducted whenever atmospherically vented combusted appliance are present in the house or garage</td>
</tr>
<tr>
<td>7</td>
<td><strong>External static pressure testing</strong></td>
<td>Units shall be tested for external static pressure (ESP) pre and post work. If there is a significant rise in ESP, airflow testing will be required</td>
</tr>
</tbody>
</table>
Topic: Ducts  
Subtopic: Duct Insulation

32) **Detail Name:** Insulating flex ducts

- **Desired Outcome:** Lower conductive heat transfer by ducts and decreased condensation on duct vapor barrier

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Removal of existing flexible ducting</td>
<td>All accessible low R-value flexible ducting will be removed from premises</td>
<td>Remove trash from workspace, Provide a clean safe workplace</td>
</tr>
<tr>
<td>2</td>
<td>Selection of new flexible ducting</td>
<td>All duct flexible ducting will have a minimum R-value of 8</td>
<td>Minimize thermal conductance of the duct system</td>
</tr>
<tr>
<td>3</td>
<td>Sizing of new flex</td>
<td>Duct sizing procedures should be conducted when replacing flex duct</td>
<td>Improve comfort in rooms, Improve fan performance</td>
</tr>
<tr>
<td>4</td>
<td>Installation of flex</td>
<td>Flex duct will be supported in accordance with manufacturer specifications and stretched to maximum length</td>
<td>Prevent sags, drops or other bends that may interfere with correct airflow</td>
</tr>
<tr>
<td>5</td>
<td>Interior liner attachment</td>
<td>Interior liner of the flex-to-metal connection will be fastened with tie bands using a tie band tensioning tool</td>
<td>Provide a strong, secure attachment</td>
</tr>
<tr>
<td>6</td>
<td>Sealing of interior liner</td>
<td>UL 181 BM listed tapes and mastic product will be used to seal this connection</td>
<td>Create an air tight connection</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Details</td>
<td>Goal</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>Attachment of exterior liner</td>
<td>Liner will be pulled up onto the metal duct as far as possible before securing. The exterior liner of the flex duct will be fastened with tie bands using a tie band tensioning tool.</td>
<td>Create a strong and durable attachment</td>
</tr>
<tr>
<td>8</td>
<td>Sealing of all accessible ducts</td>
<td>All accessible joints, seams and connections will be sealed with UL 181 approved mastics.</td>
<td>Minimize duct leakage</td>
</tr>
<tr>
<td>9</td>
<td>Insulation of all fittings</td>
<td>All metal fittings including boots, elbows and take offs will be insulated separately using a R11 duct wrap with vapor barrier.</td>
<td>Minimize thermal conductance of the duct system</td>
</tr>
<tr>
<td>10</td>
<td>Completeness of vapor barrier</td>
<td>Vapor barrier of all duct insulation will be taped to the flex duct using the taping system required by the manufacturer of the duct insulation.</td>
<td>Ensure a complete vapor barrier</td>
</tr>
</tbody>
</table>
**Topic: Ducts**  
**Subtopic: Duct Insulation**

33) **Detail Name:** Insulating Metal Ducts

- **Desired Outcome:** Lowered thermal conductance of duct system and minimized condensation on the duct system

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Selection of duct insulation material</td>
<td>Duct insulation will be a minimum of R-8 and have an attached vapor barrier</td>
<td>Decrease heat loss and condensation problems</td>
</tr>
<tr>
<td>2</td>
<td>Duct sealing</td>
<td>All accessible ducts will be sealed with a UL-approved mastic before insulation is applied</td>
<td>Minimize duct leakage</td>
</tr>
</tbody>
</table>
| 3   | Attachment of duct insulation        | Duct insulation will be secured to the duct system using metal wire or rot proof nylon twine  
Pattern of the wire or twine will be sufficient to securely hold the duct insulation tight to the duct | Ensure a secure connection between the duct system and the duct insulation |
| 4   | Taping of the duct insulation        | Using a tape approved by the manufacturer, all seams and connection of the duct insulation will be taped  
No gaps will exist between pieces of duct insulation | Prevent gaps in the vapor barrier of the insulation |
Hydronic Heating

Design:
   34) Heat Load Calculation – Whole House
   35) Space Load Calculation – Heat Emitter Sizing

Equipment:
   36) Boiler – Pressure Relief Safety Valve
   37) Boiler Replacement – Gas and Oil
   38) Controls – Thermostat Replacement

Maintenance:
   39) Gas Boiler – Annual Service
   40) Checklist
Topic: Hydronic Heating
Subtopic: Design

34) **Detail Name:** Heat Load Calculation – Whole House

**Desired Outcome:**
- A properly sized heating appliance selected

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heating load calculation</td>
<td>Heat loss of the building shell will be determined using ACCA Manual J (e.g., heat transmission, air leakage)</td>
<td>Enable proper sizing of the heating appliance</td>
</tr>
<tr>
<td>2</td>
<td>Fuel and equipment selection</td>
<td>Occupant will be educated on available fuel and equipment options, long term maintenance and cost of operation</td>
<td>Select fuel type and equipment for the house</td>
</tr>
</tbody>
</table>

109 ANSI/ASHRAE Standard 90.2-2007
110 ANSI/ASHRAE Standard 90.2-2007
Topic: Hydronic Heating  
Subtopic: Design  

35) **Detail Name:** Space Load Calculation – Heat Emitter Sizing  

**Desired Outcome:**  
- Heat emitter selected provides adequate heat output

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Space load calculation (Room by room)</td>
<td>Space load will be determined based on Air Conditioning Contractors of America (ACCA) Manual J</td>
<td>Ensure the space is properly conditioned</td>
</tr>
<tr>
<td>2</td>
<td>Heat emitter output calculation and sizing</td>
<td>Heat emitter output will be determined according to IBR and the RPA guidelines</td>
<td>Match the heat emitter size with the space load</td>
</tr>
</tbody>
</table>
**Topic: Hydronic Heating**
**Subtopic:** Equipment

### 36) Detail Name: Boiler – Pressure Relief Safety Valve

**Desired Outcome:**
- Pressure relieve valve properly installed

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Discharge tube</td>
<td>Discharge tube will be in place and intact</td>
<td>Ensure boiler discharges to a safe location and is safe to work on</td>
</tr>
<tr>
<td>2</td>
<td>Test</td>
<td>Boiler pressure will be taken to specified relief valve pressure (^{111})</td>
<td>Ensure valve discharges and reseats at specified pressure</td>
</tr>
</tbody>
</table>

\(^{111}\) NFPA 54/ANSI/AGA Z223.1
**Topic: Hydronic Heating**

**Subtopic: Equipment**

37) **Detail Name:** Boiler Replacement – Gas and Oil

**Desired Outcome:**
- Boiler replaced when needed with safe, correctly sized equipment

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Assessment 112</td>
<td>Inspections will be made for the following:</td>
<td>Determine if replacement is needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Signs of water leakage from the boiler to the Combustion Appliance Zone (CAZ)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Excessive steam in flue gases caused by water leakage to the flue side of the heat exchanger</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Heating load calculation</td>
<td>Heat loss of the building shell will be determined using ACCA Manual J (e.g., heat transmission, air leakage)</td>
<td>Enable proper sizing of the heating appliance</td>
</tr>
<tr>
<td>3</td>
<td>Fuel and equipment selection</td>
<td>Occupant will be educated on available fuel and equipment options, long term maintenance and cost of operation 113</td>
<td>Select fuel type and equipment for the house</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proper appliance size and fuel type will be selected</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Hazardous material removal</td>
<td>Health concerns in the removal and replacement of equipment will be identified</td>
<td>RemEDIATE health hazards using EPA-certified contractors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Written notification of hazardous material will be provided to the occupant</td>
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</tr>
</tbody>
</table>

112 NFPA 31

113 ANSI/ASHRAE Standard 62.2-2010
<p>| | | |</p>
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<thead>
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<tbody>
<tr>
<td></td>
<td>Contact information for the regional EPA asbestos coordinator will be provided</td>
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<tr>
<td></td>
<td>Asbestos abatement will be conducted by an EPA-certified contractor before equipment removal and replacement</td>
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<td></td>
<td>Occupant will be asked to contract with an EPA-certified asbestos contractor to conduct asbestos abatement, if applicable</td>
<td></td>
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<tr>
<td></td>
<td>Accepted industry procedures and practices will be followed to:</td>
<td>Ensure the safety of the workers, occupants and house</td>
</tr>
<tr>
<td></td>
<td>• Remove old boiler and associated components</td>
<td>Provide timely and efficient removal of old equipment</td>
</tr>
<tr>
<td></td>
<td>• Seal any unused chimney</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Remove unused oil tank, lines, valves and associated equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>New boiler and associated components will be installed to accepted industry procedures and practices</td>
<td>Ensure the safety of the workers, occupants and house</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide timely and efficient removal of old equipment</td>
</tr>
<tr>
<td></td>
<td>Circulator pump will be placed on the supply side of the system</td>
<td>Reduce maintenance and improve the efficiency of the system</td>
</tr>
<tr>
<td></td>
<td>Micro-bubble air separator will be installed according to manufacturer specifications</td>
<td>Reduce maintenance and improve the efficiency of the system</td>
</tr>
</tbody>
</table>

114 NFPA 54/ANSI/AGA Z223.1
| 9 | **Bladder expansion tank** | A bladder expansion tank will be installed 18-24” from the micro-bubble air separator, upstream of the circulator pump (pumping away from the bladder expansion tank) | Reduce maintenance and improve the efficiency of the system |
**Topic: Hydronic Heating**
**Subtopic: Equipment**

**38) Detail Name:** Controls – Thermostat Replacement

**Desired Outcome:**
- Thermostat replaced when appropriate

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Visual inspection | Thermostats will be visually located
Replacement will be recommended if a digital, double set-back thermostat is not present* | Determine if existing thermostats need to be replaced |
| 2   | Removal (if removal is recommended) | Heating system will be de-energized before removal
Thermostat will be removed
Compatibility will be verified (e.g., voltage, wiring condition, location) | |

*Location of existing thermostat will be assessed for appropriateness (e.g., central to the house, out of direct sunlight, away from supply air, protected from abnormal radiant surface temperatures)
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</table>
| 3 | **Installation** | Location for new thermostat will be determined  
Compatibility with new thermostat will be verified (e.g., voltage, wiring, condition, location)  
Replacement will be recommended if a digital, double set-back thermostat is not present*  
Heating system will be re-energized and cycled  
Thermostat will be programmed to occupant lifestyle choices |
|   |   | Provide occupant comfort and energy savings |
| 4 | **Disposal** | Thermostats will be disposed of according to EPA guidelines  
Prevent mercury from entering the environment |
| 5 | **Occupant education** | Occupant will be involved in the initial programming of thermostat and educated on common settings and programming  
On new installs, occupants will be encouraged to save the manual and keep it accessible |
|   |   | Provide understanding for best use by occupant |

*High mass, radiant systems may or may not benefit from programmable thermostats*  

---

116 NFPA 70A  
117 40 CFR 271.13  
118 ANSI/ASHRAE Standard 62.2-2010
**Topic: Hydronic Heating**  
**Subtopic:** Maintenance

39) **Detail Name:** Gas Boiler – Annual Service

**Desired Outcome:**
- Boiler service improves safety, efficiency and performance

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<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Health and safety</td>
<td>The Building Performance Institute (BPI) protocol for Combustion Appliance Zone (CAZ) combustion safety testing will be administered</td>
<td>Identify potential health and safety issues</td>
</tr>
</tbody>
</table>
| 2   | Visual inspection<sup>120</sup> | The following conditions will be assessed:  
  - Water, steam and fuel leaks  
  - Damaged or missing pipe insulation  
  - Venting Issues – draft and condensation (e.g., soot, rusting of flue pipe, burned paint or wires, efflorescence)  
  - Corrosion (e.g., rust, mineral deposits)  
  - General condition of components | Observe general conditions to determine needed repairs or maintenance |

<sup>119</sup> ASTM E1998 - 02(2007)  
<sup>120</sup> NFPA 54/ANSI/AGA Z223.1
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<tbody>
<tr>
<td></td>
<td><strong>Gas valves</strong></td>
<td>Gas valves will be removed and replaced according to manufacturer specifications ¹²¹</td>
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<tr>
<td></td>
<td>Provide gas to burner when there is a call for heat</td>
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<td></td>
<td>Control volume of gas for burner</td>
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<td></td>
<td>Ensure the safe shut-off of gas at the end of a call for heat</td>
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<tr>
<td></td>
<td><strong>Ignition system</strong></td>
<td>Components of ignition system will be repaired or replaced according to manufacturer specifications ¹²²</td>
</tr>
<tr>
<td></td>
<td>Do not allow flow of main burner gas without proof of ignition</td>
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<tr>
<td></td>
<td><strong>Main gas burners</strong></td>
<td>Problems that may interfere with flame (e.g., dust, debris, misalignment) will be cleaned, vacuumed and adjusted ¹²³</td>
</tr>
<tr>
<td></td>
<td>Produce combustion in a safe, clean and efficient manner</td>
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<tr>
<td></td>
<td><strong>Venting</strong></td>
<td>Flue gases will be removed from the venting system in accordance with Section 504, IFGC for gas boilers ¹²⁴</td>
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<tr>
<td></td>
<td>Ensure the safety and durability of the venting system</td>
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</tr>
<tr>
<td></td>
<td><strong>Combustion testing</strong> ¹²⁵</td>
<td>Undiluted flue gases will be checked with a calibrated flue gas analyzer according to accepted protocol (e.g., BPI, NATE)</td>
</tr>
<tr>
<td></td>
<td>Confirm that combustion occurs safely with maximum efficiency</td>
<td></td>
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</tbody>
</table>

¹²¹ NFPA 54/ANSI/AGA Z223.1
¹²² NFPA 54/ANSI/AGA Z223.1
¹²³ NFPA 54/ANSI/AGA Z223.1
¹²⁴ NFPA 54/ANSI/AGA Z223.1
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<tr>
<td>8</td>
<td>De-rating non-modulating systems under 90% annual fuel utilization efficiency (AFUE)</td>
<td>Undiluted flue gases will be checked with a calibrated flue gas analyzer according to accepted protocol (e.g., BPI, NATE) to determine if acceptable boiler efficiency is being maintained. If boilers are found to be out of compliance, a combustion analysis will be administered and minimum stack temperature will be met as prescribed by the manufacturer or IFGC504. Increase the operational efficiency of the system and improve occupant comfort.</td>
</tr>
<tr>
<td>9</td>
<td>Occupant health</td>
<td>Carbon monoxide (CO) monitors will be installed in all houses with Category I appliances. Ensure ambient CO does not exceed acceptable levels after completion of work.</td>
</tr>
<tr>
<td>10</td>
<td>Occupant education</td>
<td>Occupants will be educated on the operation and maintenance of the CO monitor. Completed work and recommended maintenance will be reviewed. Ensure occupant is informed of the safe and efficient operation and maintenance of the work performed.</td>
</tr>
</tbody>
</table>

126 NFPA 54/ANSI/AGA Z223.1
127 NFPA 720
128 ANSI/ASHRAE Standard 62.2-2010
### Topic: Hydronic Heating

**Subtopic: Maintenance**

40) **Detail Name:** Checklist

**Desired Outcome:**
- Thorough maintenance improves safety, efficiency and performance

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<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Health and safety</td>
<td>The Building Performance Institute (BPI) protocol for Combustion Appliance Zone (CAZ) combustion safety testing will be administered (^{129})</td>
<td>Identify potential health and safety issues</td>
</tr>
<tr>
<td>2</td>
<td>Visual inspection(^{130})</td>
<td>The following conditions will be inspected:</td>
<td>Observe general conditions to determine needed repairs or maintenance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Water, steam and fuel leaks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Damaged or missing pipe insulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Venting Issues – draft and condensation (e.g., soot, rusting of flue pipe, burned paint or wires, efflorescence)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Corrosion (e.g., rust, mineral deposits)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• General condition of components</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Pipe insulation inspection</td>
<td>Pipe insulation will be inspected, including:</td>
<td>Minimize heat loss and improve performance of the system</td>
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<tr>
<td></td>
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<td>• Integrity – complete coverage, no holes or tears</td>
<td></td>
</tr>
</tbody>
</table>

\(^{129}\) ASTM E1998 - 02(2007)

\(^{130}\) NFPA 54/ANSI/AGA Z223.1
- Damage – holes or tears
- Complete coverage – insulation missing

If asbestos is suspected, occupants will be notified and asbestos will not be disturbed

Required repair or replacement will be performed according to the following conditions:
- Materials will be approved for steam heating pipes
- Materials will be approved for hot water heating pipes
- Insulation will completely cover pipe

Pipe insulation will be installed according to manufacturer specifications

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<td>4</td>
<td>Check system pressure</td>
<td>Check system pressure will be verified</td>
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<td></td>
<td>Check system pressure will be 1 pound per square inch gauge (psig) per 28” of system height</td>
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<td>Keep system operating within pressure parameters</td>
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<tr>
<td>5</td>
<td>Purge system</td>
<td>Each accessible heat emitter will be purged</td>
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<td>Remove air from the system to maximize performance</td>
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<tr>
<td>6</td>
<td>Automatic fill</td>
<td>Automatic fill valve will be inspected to ensure it maintains system pressure</td>
</tr>
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<td></td>
<td>Maintain optimal system pressure to maximize performance</td>
</tr>
</tbody>
</table>

\[^{131}\text{NFPA 54/ANSI/AGA Z223.1}\]
<table>
<thead>
<tr>
<th>7</th>
<th><strong>Gauge glass</strong></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Gauge glass will be inspected for erosion, cracks or drying</td>
</tr>
<tr>
<td></td>
<td>Damaged gauge glass on boiler will be replaced according to manufacturer specifications</td>
</tr>
<tr>
<td></td>
<td>Ensure gauge glass is in safe operating condition to allow observation of water level in boiler</td>
</tr>
</tbody>
</table>

maintained, replacement will be made in accordance with the following criteria:

- Valve will be replaced with backflow prevention
- Components will be installed according to manufacturer specifications
- Correct system pressure will be verified
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</table>
| 8 | **Low water cut-off:** Float type[^132] | Operation of low water cut-off will be observed by opening blow-off valve

If combustion is not extinguished, remediation will be accomplished by the following procedure:

- Electricity will be disconnected from boiler
- Problem will be diagnosed
- Low water cut-off will be repaired, serviced, or replaced according to manufacturer specifications
- Boiler will be retested for proper operation

Occupants will be educated on the correct method to drain the low water cut-off weekly (must drain once per week to remove sediment from float chamber of low water cut-off)

Ensure safe minimum water level of the boiler

Maintain safe operation of the low water cut-off on ongoing basis

| 9 | **Low water cut-off:** Immersion[^133] | An immersion low-water cut off will be installed and operable

Ensure safe minimum water level of the boiler

| 10 | **Expansion tank:** Non-bladder and bladder | An expansion tank will be installed and operable

Tanks that leak or have excessive corrosion will be replaced and non-bladder tanks will include an

Absorb water expansion of the system

[^132]: NFPA 54/ANSI/AGA Z223.1
[^133]: NFPA 54/ANSI/AGA Z223.1
<table>
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<tr>
<th></th>
<th></th>
<th>expansion tank drain</th>
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<tr>
<td></td>
<td></td>
<td>Tank will be installed according to manufacturer specifications</td>
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<td></td>
<td></td>
<td>Expansion tanks will be properly supported with strapping</td>
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<tr>
<td></td>
<td></td>
<td>Tanks that are full of water will be drained and refilled before being replaced or repaired</td>
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<td>Expansion tanks with bladders will have air charged to the manufacturer pressure specifications while water is not present in the tank</td>
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<td></td>
<td>Bladder tanks that have water inside of the air bladder will be replaced according to manufacturer specifications</td>
</tr>
<tr>
<td>11</td>
<td>Flush or skim steam boiler</td>
<td>Manufacturer specifications for flushing or skimming steam boiler will be followed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ensure boiler produces dry steam</td>
</tr>
<tr>
<td>12</td>
<td>System temperature or pressure gauge $^{134}$</td>
<td>The temperature or pressure gauge will be inspected for erosion, cracks or dirt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Damaged temperature or pressure gauges will be replaced according to manufacturer specifications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Allow accurate observation of system temperature and pressure</td>
</tr>
<tr>
<td>13</td>
<td>Circulators</td>
<td>Non-working motors that cannot be serviced will be replaced with a new motor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ensure circulation of water at designated velocity in system without leaks in the circulators</td>
</tr>
</tbody>
</table>

$^{134}$ NFPA 54/ANSI/AGA Z223.1
<table>
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<tr>
<th></th>
<th></th>
<th>New motors will be installed according to manufacturer specifications</th>
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<tbody>
<tr>
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<td>Oil lubricated circulators will be installed in proper alignment with the pump coupler and will be supported so they do not sag</td>
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<td></td>
<td>Bearings will have free movement and no water leakage</td>
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<td></td>
<td>Bearings in inoperable, water lubricated circulators will be freed if possible before replacement with a new circulation pump</td>
</tr>
</tbody>
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<tr>
<th>14</th>
<th>Zone valves</th>
<th>Zone valves will be inspected for the following conditions:</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>• Leaking water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Not responding to a call for heat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New equipment will be replaced according to manufacturer specifications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ensure proper zonal control of the system for comfort and efficiency</td>
</tr>
</tbody>
</table>

<p>| 15 | Condensate | If boiler is 90% efficient or more, condensate discharge will be an acceptable pH and will be drained to the exterior of the house, away from the foundation. |
|    |            | Condensate pumps will be installed if needed to ensure proper drainage |
|    |            | Bring the condensate to an acceptable pH and discharge to appropriate location |</p>
<table>
<thead>
<tr>
<th></th>
<th>Temperature, pressure valves and air vents</th>
<th>Occupant will be informed that air vents have potential to cause moisture problems if not operating properly. Occu- pant will be reminded to call for maintenance if vents discharge steam or have moisture issues.</th>
<th>Maintain efficient operation of the system</th>
</tr>
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<tr>
<td></td>
<td>Maintenance records</td>
<td>Keeping records of all maintenance will be recommended to occupants. Copies or access to installation and operation manuals will be provided.</td>
<td>Provide a history of system installation and maintenance to improve chance of successful future maintenance or repair.</td>
</tr>
<tr>
<td></td>
<td>Occupant health and safety</td>
<td>Ambient carbon monoxide (CO) levels will be less than accepted industry levels after work is complete. CO monitors will be installed in all houses without existing monitor.</td>
<td>Ensure ongoing health and safety of occupants.</td>
</tr>
<tr>
<td></td>
<td>Occupant education</td>
<td>Completed work will be reviewed. Occupants will be educated on the safe and efficient operation and maintenance of the system.</td>
<td>Ensure occupant is informed of the safe, efficient operation and maintenance of the system.</td>
</tr>
</tbody>
</table>

135 NFPA 54/ANSI/AGA Z223.1
136 ANSI/ASHRAE Standard 62.2-2010
137 NFPA 720
138 NFPA 720
139 ANSI/ASHRAE Standard 62.2-2010
SECTION 6: INSULATION

Table of Contents

Health and Safety

Safe Work Practices: ¹
1) Insulation Worker Safety

Attic

Preparation:
2) Non-Insulation Contact (IC) Recessed Light
3) Knob and Tube Wiring
4) Fireplace Chimney and Combustion Flue Vents
5) Vented Eave or Soffit Baffles
6) Dense Pack Preparation

Attic Ceilings:
7) Loose Fill Over Pitched Ceilings
8) Dense Pack Over Pitched Ceilings
9) Unvented Flat Roof with Existing Insulation
10) Dense Pack Cape Cod Side Attic Roof

Knee Walls:
11) Preparation for Dense Packing
12) Preparation for Batt Insulation
13) Strapping for Existing Insulation
14) Knee Wall without Framing

Accessible Attic Floors:
15) Batt Installation
16) Loose Fill Installation
17) Loose Fill Over Existing Insulation
18) Batt Insulation Over Existing Insulation

Enclosed Attic Floors:
19) Dense Pack Installation – Bonus Room Floor
20) Dense Pack Installation – Attic Storage Platform

¹ Appendix D – OSHA Personal Protective Equipment Standards
Attic Openings:
   21) Pull Down Stairs
   22) Access Doors and Hatches
   23) Whole-House Fan

Attics General:
   24) Ventilation
   25) Radiant Barrier
   26) Skylights
   27) Parapet Walls

Exterior Walls

Preparation:
   28) Exterior Dense Pack

Accessible Exterior Walls:
   29) Open Wall Insulation

Enclosed Exterior Walls:
   30) Dense Pack Exterior Walls
   31) Additional Exterior Wall Cavities

Floors

Accessible Floors:
   32) Batt Installation Floor System
   33) Loose Fill Floor System with Netting
   34) Loose Fill Floor System with Rigid Barrier
   35) Batt Installation Cantilevered Floor
   36) Pier house subfloor insulation – Batt installation with rigid barrier
   37) Pier house subfloor insulation – loose fill with rigid barrier
Health and Safety

Safe Work Practices:

1) Insulation Worker Safety
**Topic: Health and Safety**  
**Subtopic: Safe Work Practices**

1) **Detail Name:** Insulation Worker Safety

**Desired Outcome:**
- Work is completed safely without injury or hazardous exposure

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<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
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</table>
| 1   | Hand protection            | Durable and wrist protecting gloves will be worn that can withstand work activity \(^2\)                                                                                                                                                                                                                             | Minimize skin contact with contaminants  
Protect hands from sharp objects                                                                                                                 |
| 2   | Respiratory protection     | Respirators appropriate for the contaminants present will be worn (e.g. N-95 or equivalent face mask) \(^3\) \nOSHA asbestos abatement protocol 1926.1101 will be followed if vermiculite insulation is present                                                                                                           | Minimize exposure to airborne contaminants (e.g. insulation materials, mold spores, feces, bacteria, chemicals)  
Protect workers from toxic exposure                                                                                                              |
| 3   | Electrical safety \(^4,5\) | An electrical safety assessment will be performed  
All electric tools will be protected by Ground-Fault Circuit Interrupters \(^6\)  
Extension cords used with portable electric tools will be of three-wire type  
Worn or frayed electric cords will not be used                                                                                                                                                     | Avoid electrical shock and arc flash hazards                                                                                                           |

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\(^2\) OSHA Technical Manual Section VIII: Chapter 1, part III  
\(^3\) OSHA Technical Manual Section VIII: Chapter 2, section IV  
\(^5\) 29 CFR 1926 Subpart K – Electrical  
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<td><strong>7 Chemical safety</strong></td>
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<td>The least toxic suitable material will be chosen</td>
<td>Prevent toxic exposure to workers</td>
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<td>Chemicals will be handled according to manufacturer specifications or MSDS standards to eliminate hazards associated with VOCs, sealants, insulation, contaminated drywall, dust, foams, asbestos, lead, fibers, incorrect, defective or improperly used respirator and Personal Protective Equipment (PPE)</td>
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<td><strong>8 Ergonomic safety</strong></td>
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<td>Personal Protective Equipment will be used (e.g. knee pads, bump caps, additional padding)</td>
<td>Avoid injuries with awkward postures and repetitive motions</td>
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<td>Proper equipment will be used for work</td>
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<td><strong>9 Hand tool safety</strong></td>
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<td>Hand tools will be used for intended purpose</td>
<td>Reduce injuries</td>
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11 Appendix D – OSHA Personal Protective Equipment Standards
12 29 CFR 1910 Subpart Z - Toxic and Hazardous Substances
14 29 CFR 1910 Subpart P - Hand and portable powered tools and other hand-held equipment
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<tr>
<td>10</td>
<td>Slips, trips and falls</td>
<td>Caution will be used around power cords, hoses, tarps and plastic sheeting</td>
<td>Eliminate injuries due to slips, trips and falls</td>
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<td>Precautions will be taken when ladders are used, when working at heights, or when balancing on joists</td>
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<td>Appropriate footwear and clothing will be worn</td>
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<td>Heat and thermal stress</td>
<td>Appropriate ventilation, hydration, rest breaks and cooling equipment will be used</td>
<td>Reduce heat stroke, heat stress and cold stress related injuries</td>
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<td>Dial 911 when necessary</td>
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<td>Fire safety</td>
<td>Ignition sources will be identified and eliminated (e.g. turn off pilot lights and fuel supply)</td>
<td>Prevent a fire hazard</td>
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<td>Flammable material will be reduced and fire-rated materials will be used</td>
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15 29 CFR 1926 Subpart M - Fall Protection
16 29 CFR 1926 Subpart C - General Safety and Health Provisions
17 Appendix D – OSHA Personal Protective Equipment Standards
<table>
<thead>
<tr>
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<th>Vermiculite safety</th>
<th>Lead paint assessment</th>
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| 13 | OSHA asbestos abatement protocol 1926.1101 will be followed if vermiculite insulation is present  
If unsure whether material contains asbestos, a qualified asbestos professional will be contacted to assess the material and sample and test as needed  
When working around Asbestos containing material (ACM), the following will not be done:  
- Dust, sweep or vacuum debris  
- Saw, sand, scrape or drill holes in the material  
- Use abrasive pads or brushes to strip materials  
Attic insulation that looks like vermiculite (as opposed to fiberglass, cellulose or urethane foams) will not be removed or disturbed  
Protect workers from toxic exposure | Presence of lead based paint in pre-1978 homes will be assumed unless testing confirms otherwise  
Comply with EPA’s Renovation, Repair and Painting (RRP) Program Rule  
Protect worker and occupant from potential lead hazards |
(40 CFR Part 745) in pre-1978 homes and proposed changes to this rule (Federal Register/Vol. 75, No. 87/ May 6, 2010), to be superseded by any subsequent final rulemaking or any more stringent state or Federal standards.
Attic

Preparation:
2) Non-Insulation Contact (IC) Recessed Light
3) Knob and Tube Wiring
4) Fireplace Chimney and Combustion Flue Vents
5) Vented Eave or Soffit Baffles
6) Dense Pack Preparation

Attic Ceilings:
7) Loose Fill Over Pitched Ceilings
8) Dense Pack Over Pitched Ceilings
9) Unvented Flat Roof with Existing Insulation
10) Dense Pack Cape Cod Side Attic Roof

Knee Walls:
11) Preparation for Dense Packing
12) Preparation for Batt Insulation
13) Strapping for Existing Insulation
14) Knee Wall without Framing

Accessible Attic Floors:
15) Batt Installation
16) Loose Fill Installation
17) Loose Fill Over Existing Insulation
18) Batt Insulation Over Existing Insulation

Enclosed Attic Floors:
19) Dense Pack Installation – Bonus Room Floor
20) Dense Pack Installation – Attic Storage Platform

Attic Openings:
21) Pull Down Stairs
22) Access Doors and Hatches
23) Whole-House Fan

Attics General:
24) Ventilation
25) Radiant Barrier
26) Skylights
27) Parapet Walls
## Topic: Attic Floor
### Subtopic: Preparation

2) **Detail Name:** Non-Insulation Contact (IC) Recessed Light

**Desired Outcome:**
- An air barrier ensures safety from fire and prevents leakage

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<th>Specification(s)</th>
<th>Objective(s)</th>
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| 1   | Air barrier system | An air barrier system will be used to separate non-IC rated recessed lights from insulation, using one of the methods below:  
An airtight closure taller than surrounding attic insulation will be placed over non-IC rated recessed lights  
OR  
The non-IC rated light fixture will be replaced with an airtight and IC-rated fixture | Prevent a fire hazard  
Prevent air leakage through fixture 18 |
| 2   | Enclosure top    | The top enclosure material will have an R-value of 0.5 or less  
The top of the enclosure will be left free of insulation | Prevent heat build up |
| 3   | Clearance        | The closure will maintain a 3" clearance between the closure and the fixture including wiring, box and ballast | Keep an air space around the fixture |

18 ASTM E1186 - 03(2009)
|   | **4** | Sealants and weatherstripping | Caulk, mastic or foam will be used on all edges, gaps, cracks, holes and penetrations of closure material only | Completely adhere the sealant to all surfaces to be sealed to prevent air leakage $^{19}$ |

$^{19}$ ASTM E1186 - 03(2009)
**Topic: Attic**  
**Subtopic: Preparation**

3) **Detail Name:** Knob and Tube Wiring

**Desired Outcome:**
- Insulation kept away from contact with live wiring

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</thead>
<tbody>
<tr>
<td>1</td>
<td>Identifying knob and tube wiring</td>
<td>The house will be visually inspected to identify knob and tube wiring</td>
<td>Determine if knob and tube wiring exists</td>
</tr>
</tbody>
</table>
| 2   | Testing to determine if live | Non contact testing method will be used to identify live wiring | Ensure safety of occupants, workers, and house  
Plan where remediation is needed |
| 3   | Isolate and protect | Live knob and tube will not be covered or surrounded (required NEC)  
A licensed electrical contractor will inspect and certify wiring to be safe and place a warning at all entries to the attic about the presence of knob and tube wiring  
A dam that does not cover the top will be created to separate insulation from the wire path | Ensure work can be completed safely |
| 4   | Replace | Knob and tube wiring will be replaced with new appropriate wiring by a licensed electrician according to local codes  
Remaining knob and tube wiring will be rendered | Protect occupant and house  
Ensure future work can be done safely |
| inoperable by licensed electrician according to local codes |
**Topic: Attic**

**Subtopic: Preparation**

4) **Detail Name:** Fireplace Chimney and Combustion Flue Vents

**Desired Outcome:**
- Combustible materials kept away from combustion sources

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Verify attic prep</td>
<td>Holes, penetrations and bypasses will be sealed</td>
<td>Prevent air leakage 20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dams will be fixed in places that maintain required clearance</td>
<td>Ensure insulation dams maintain clearance</td>
</tr>
<tr>
<td>2</td>
<td>Required clearance</td>
<td>A rigid dam having a height greater than the insulation to be installed will be</td>
<td>Ensure dam material does not bend, move or sag</td>
</tr>
<tr>
<td></td>
<td></td>
<td>constructed to ensure a 3” clearance between combustion flue vent and dam</td>
<td>Prevent a fire hazard</td>
</tr>
<tr>
<td>3</td>
<td>Safety</td>
<td>Insulation will not be allowed between a heat-generating appliance and a dam</td>
<td>Prevent a fire hazard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unless material is rated for contact with heat-generating sources 21</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Occupant education</td>
<td>Documentation of material and R-value will be provided to occupant 22</td>
<td>Provide occupant with documentation of installation</td>
</tr>
</tbody>
</table>

20 ASTM E1186 - 03(2009)
21 ASTM C1015 - 06
22 16CFR460.17
Topic: Attic
Subtopic: Preparation

5) Detail Name: Vented Eave or Soffit Baffles

Desired Outcome:
- Attic ventilation meets code requirements and insulation protected from wind washing

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Installation</td>
<td>Baffles will be mechanically fastened to block wind entry into insulation or to prevent insulation from blowing back into the attic</td>
<td>Ensure insulation R-value is not reduced</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Baffles will be installed to maintain clearance between the roof deck and baffle according to manufacturer specifications</td>
<td>Maintain attic ventilation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Installation will allow for the highest possible R-value above the top plate of the exterior wall</td>
<td></td>
</tr>
</tbody>
</table>

**Topic: Attic**

**Subtopic: Preparation**

6) **Detail Name:** Dense Pack Preparation

**Desired Outcome:**
- Proper material density achieved safely and cleanly

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Preparation</td>
<td>Lead safety procedures will be followed</td>
<td>Prevent damage to house, Provide thorough access to allow 100% coverage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cavities will be free of hazards, intact and able to support dense pack pressures</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All escape openings will be blocked for material</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Access will be gained and each cavity will be probed, locating all attic floor</td>
<td>Use proper equipment and process to achieve consistent density, prevent settling and retard air flow through cavities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>joists and blockers</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interior will be masked and dust controlled during drilling when accessing from</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>the interior</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electricity supply will be confirmed and will support blowing machine power</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>demand</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blowing machine pressure test will be performed with air on full, feed off and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>gate closed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hose outlet pressure will be at least 80 inches of water column (IWC) or 2.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>pounds per square inch (PSI)</td>
<td></td>
</tr>
</tbody>
</table>
Topic: Attic  
Subtopic: Attic Ceilings

7) Detail Name: Loose Fill Over Pitched Ceilings

**Desired Outcome:**
- Insulation controls heat transfer through cathedral or vaulted ceiling

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ventilation</td>
<td>Venting will be continuous, if applicable</td>
<td>Ensure capacity to increase R-value while not altering ventilation</td>
</tr>
<tr>
<td>2</td>
<td>Lighting</td>
<td>Existence of rated insulation-contact can lights, which allow for insulation encapsulation, will be verified</td>
<td>Prevent a fire hazard</td>
</tr>
<tr>
<td>3</td>
<td>Installation</td>
<td>When using cellulose, only stabilized product will be used</td>
<td>Ensure appropriate material and application</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loose fill fiber glass will only be used on a slope less than or equal to a 6:12 pitch or the slope application approved by the manufacturer, whichever is less</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roof cavities will be insulated with loose fill according to manufacturer specifications without gaps, voids, compressions, misalignments or wind intrusions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation will be installed</td>
<td></td>
</tr>
</tbody>
</table>

23 ASTM C1015 - 06  
24 ASTM C1015 - 06
<p>| | | | |</p>
<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td><strong>Occupant education</strong></td>
<td>Documentation of material and R-value will be provided to occupant 25</td>
<td>Provide occupant with documentation of installation</td>
</tr>
</tbody>
</table>
**Topic: Attic**

**Subtopic: Attic Ceilings**

8) **Detail Name:** Dense Pack Over Pitched Ceilings

**Desired Outcome:**
- Insulation reduces heat transfer through ceiling and closed attic sections as well as framing cavities inaccessible to other treatments

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Fill slant ceilings       | Using fill tube, 100% of each cavity will be completely filled to a consistent density:  
- Cellulose material will be installed to a minimum density of 3.5 pounds per cubic foot  
- Loose fiber glass material will be installed and will be specifically approved for air flow resistance to a minimum density of 2.2 pounds per cubic foot  
The number of bags installed will be confirmed and will match the number required on the coverage chart 26  
Insulation will be verified to prevent visible air movement using chemical smoke at 50 Pascals of pressure difference 27 | Ensure complete and consistent coverage throughout ceiling plane  
Eliminate voids and settling  
Minimize framing cavity air flows |

---

26 16CFR460.17  
27 ASTM E1186 - 03(2009)
**Topic: Attic**

**Subtopic:** Attic Ceilings

9) **Detail Name:** Unvented Flat Roof with Existing Insulation

**Desired Outcome:**
- Insulation reduces heat flow through unvented roof

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ventilation</td>
<td>Code-compliant ventilation will be installed before insulation</td>
<td>Reduce possibility of moisture issues</td>
</tr>
<tr>
<td>2</td>
<td>Installation</td>
<td>Roof cavities will be blown with loose fill insulation without gaps, voids,</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>compressions, misalignments or wind intrusions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation will be installed to prescribed R-value</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Occupant education</td>
<td>Documentation of material and R-value will be provided to occupant</td>
<td>Provide occupant with documentation of installation</td>
</tr>
</tbody>
</table>

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28 ASTM C1015 - 06
**Topic: Attic**

**Subtopic: Attic Ceilings**

10) **Detail Name:** Dense Pack Cape Cod Side Attic Roof

**Desired Outcome:**
- Consistent, uniform thermal boundary between conditioned and unconditioned space

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Engineer, architect approval</td>
<td>Engineer or architect approval will be obtained before insulating</td>
<td>Verify design change</td>
</tr>
<tr>
<td>2</td>
<td>Vapor barrier removal</td>
<td>Vapor barriers will be removed from existing attic floor</td>
<td>Ensure the new conditioned space is coupled with the house</td>
</tr>
<tr>
<td>3</td>
<td>Netting, fabric, rigid sheathing</td>
<td>When using netting or fabric, staples will be placed every 1 ½&quot; on center</td>
<td>Secure insulation in place</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Netting or fabric will meet local fire codes 29</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rigid materials will close the cavity</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Installation</td>
<td>Roof cavities will be dense packed with loose fill insulation according to manufacturer density specifications 30</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation will be installed to prescribed R-value</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Onsite documentation</td>
<td>Documentation will be posted as required by federal specification</td>
<td>Post documentation onsite to allow verification</td>
</tr>
</tbody>
</table>

29 ASTM E84 - 10
30 ASTM C1015 - 06
<table>
<thead>
<tr>
<th></th>
<th>16CFR460</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Occupant education</td>
<td>Documentation of material and R-value will be provided to occupants (^{31})</td>
</tr>
</tbody>
</table>

\(^{31}\) 16CFR460.17
**Topic: Attic**  
**Subtopic: Knee Walls**

11) **Detail Name:** Preparation for Dense Packing

**Desired Outcome:**
- Airtight cavity and insulated knee wall

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Backing</td>
<td>All knee walls will have a top and bottom plate or blockers installed using a rigid material</td>
<td>Eliminate bending, sagging or movement that may result in air leakage</td>
</tr>
</tbody>
</table>
|     |         | If fabric is used before dense packing, it will be secured with 1” crown staples every 2” or furring strips every wall stud                                                                                         | Prevent air leakage through the top or bottom of the knee wall  
32                                                                                                                                                                                                         |
|     |         | If rigid material is used, material will be installed to cover 100% of the surface of the accessible knee wall area                                                                                               | Ensure material will not tear under stress from wind loads or insulation                                                                                                                                   |
|     |         | If foam sheathing is used, sheathing will be listed for uncovered use in an attic, or covered with a fire barrier                                                                                                    |                                                                                                                                                                                                             |

32 ASTM E1186 - 03(2009)
| 2 | Installation | All existing batted insulation will be adjusted to ensure it is in full contact with the interior cladding and top and bottom plates. Insulation that is blown behind fabric or air barrier material will be blown dense to a minimum specification of 3.5 pounds per cubic foot for cellulose or 2.2 pounds per cubic foot for fiber glass. | Eliminate misalignment of existing insulation. Prevent insulation settling or movement. |
**Topic: Attic**  
**Subtopic:** Knee Walls

12) **Detail Name:** Preparation for Batt Insulation

**Desired Outcome:**
- Airtight cavity and properly insulated knee wall

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Knee wall prep for batts | All knee walls will have a top and bottom plate or blockers installed using a rigid material  
All joints, cracks and penetrations will be sealed in finished material including interior surface to framing connections | Eliminate bending, sagging or movement that may result in air leakage  
Prevent air leakage through the top or bottom of the knee wall  
Create an air barrier |
| 2   | Installation           | Insulation will be installed using one of the following methods:      
New batts will be installed  
All existing batted insulation will be adjusted to ensure it is in full contact with the interior cladding and top and bottom plates | Eliminate misalignment of existing insulation |
| 3   | Backing knee wall       | If rigid material is used, material will be installed to cover 100% of the surface of the knee wall  
If foam sheathing is used, sheathing will be listed for uncovered use in an attic, or covered with a fire barrier | Prevent insulation settling or movement |

33 ASTM E1186 - 03(2009)
**Topic: Attic**
**Subtopic: Knee Walls**

13) **Detail Name:** Strapping for Existing Insulation

**Desired Outcome:**
- Consistent, uniform thermal boundary between the conditioned space and unconditioned space to prescribed R-value

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sealing</td>
<td>Holes and penetrations will be sealed</td>
<td>Prevent air leakage $^{35}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bypasses will be blocked and sealed</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Installation</td>
<td>Insulation will be installed in full contact with all sides of existing cavity without gaps, voids, compressions, misalignments or wind intrusions $^{36}$</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td>3</td>
<td>Attachment</td>
<td>Strapping material will have a minimum expected service life of 20 years</td>
<td>Maintain alignment</td>
</tr>
<tr>
<td>4</td>
<td>Occupant education</td>
<td>Documentation of material and R-value will be provided to occupant $^{37}$</td>
<td>Provide occupant with documentation of installation</td>
</tr>
</tbody>
</table>

$^{34}$ ASTM E1186 - 03(2009)
$^{35}$ ASTM E1186 - 03(2009)
$^{36}$ ASTM C 1320-05 (09)
$^{37}$ 16CFR460.17
**Topic: Attic**  
**Subtopic: Knee Walls**

14) **Detail Name:** Knee Wall without Framing

**Desired Outcome:**  
- Consistent uniform thermal boundary between the conditioned space and unconditioned space to prescribed R-value

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sealing</td>
<td>Holes and penetrations will be sealed</td>
<td>Prevent air leakage&lt;sup&gt;39&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bypasses will be blocked and sealed&lt;sup&gt;38&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Flat cavity present</td>
<td>Gap between framing and existing air barrier will be insulated</td>
<td>Create a flat insulated surface</td>
</tr>
<tr>
<td>3</td>
<td>Installation</td>
<td>A rigid-insulated sheathing will be mechanically fastened to code required R-value</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seams will be sealed&lt;sup&gt;40&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Occupant education</td>
<td>Documentation of material and R-value will be provided to occupant&lt;sup&gt;41&lt;/sup&gt;</td>
<td>Provide occupant with documentation of installation</td>
</tr>
</tbody>
</table>

<sup>38</sup> ASTM E1186 - 03(2009)  
<sup>39</sup> ASTM E1186 - 03(2009)  
<sup>40</sup> ASTM E1186 - 03(2009)  
<sup>41</sup> 16CFR460.17
Topic: Attic  
Subtopic: Accessible Attic Floors

15) **Detail Name:** Batt Installation – Attic Floors

**Desired Outcome:**
- A consistent, thermal boundary between conditioned and unconditioned space controls the heat flow

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Preparation | If knee wall attic- knee wall floor space will be accessible  
Subfloor or drywall will be removed to access cavities as necessary  
All electrical junctions will be flagged to be seen above the level of the insulation  
Open electrical junction boxes will have covers installed | Access the workspace  
Provide location of electrical junctions for future servicing  
Prevent an electrical hazard |
| 2   | For knee wall attics: Air barrier | Existence of air barrier material in line with the knee walls will be installed or verified when dense packing  
Air barrier material will not bend, sag or move once dense packed | Hold dense pack in place |
<table>
<thead>
<tr>
<th></th>
<th>Installation</th>
<th>Batt insulation will be installed according to manufacturer specifications without gaps, voids, compressions, misalignments or wind intrusions 42</th>
<th>Insulate to prescribed R-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Occupant education</td>
<td>Documentation of material and R-value will be provided to occupant 43</td>
<td>Provide occupant with documentation of installation</td>
</tr>
</tbody>
</table>

42 ASTM C 1320-05 (09)
43 16CFR460.17
### Topic: Attic

**Subtopic: Accessible Attic Floors**

#### 16) Detail Name: Loose Fill Installation – Attic Floors

**Desired Outcome:**
- A consistent, thermal boundary between conditioned and unconditioned space controls the heat flow

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Preparation</td>
<td>If knee wall attic- knee wall floor space will be accessible</td>
<td>Access the workspace</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subfloor or drywall will be removed to access cavities as necessary</td>
<td>Verify uniformity of insulation material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation rulers will be installed every 300 square feet of attic area with measurement beginning at the air barrier</td>
<td>Provide location of electrical junctions for future servicing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All electrical junctions will be flagged to be seen above the level of the insulation</td>
<td>Prevent an electrical hazard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open electrical junction boxes will have covers installed</td>
<td></td>
</tr>
</tbody>
</table>

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44. IECC 303.1.1.1
<p>| | | | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td><strong>For knee wall attics: Air</strong></td>
<td>Existence of air barrier material in line with the knee walls will be installed or verified when dense packing</td>
<td>Hold dense pack in place</td>
</tr>
<tr>
<td></td>
<td><strong>barrier</strong></td>
<td>Air barrier material will not bend, sag or move once dense packed</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>Installation</strong></td>
<td>All insulation will be installed to the depth indicated on the manufacturer coverage chart for desired R-value</td>
<td>Reduce heating and air conditioning costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Improve comfort</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Provide a quieter house</td>
</tr>
<tr>
<td>4</td>
<td><strong>Onsite documentation</strong></td>
<td>A signed and dated attic card will be provided that includes:</td>
<td>Document job completion to contract specifications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Insulation type</td>
<td>Confirm amount of insulation installed in attic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Installed thickness and settled thickness</td>
<td>Ensure ability to match bags required for total area completed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Coverage area</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• R-value</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Number of bags installed as per manufacturer specifications</td>
<td></td>
</tr>
</tbody>
</table>

45 ASTM C1015 - 06
46 16CFR460.17
**Topic: Attic**  
**Subtopic: Accessible Attic Floors**

17) **Detail Name:** Loose Fill Over Existing Insulation

**Desired Outcome:**
- Insulation controls heat transfer through ceiling

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Preparation|Existing insulation will be in contact with the air barrier prior to installing additional insulation on top  
Insulation rulers will be installed every 300 square feet of attic area with measurement beginning at the air barrier  
All electrical junctions will be flagged to be seen above the level of the insulation  
Open electrical junction boxes will have covers installed| Ensure proper performance of insulation  
Verify uniformity of insulation material  
Provide location of electrical junctions for future servicing  
Prevent an electrical hazard |

| 2   | Installation| The correct depth and number of bags will be blown according to manufacturer specifications  
Insulation will be installed to prescribed R-value | Insulate to prescribed R-value |

---

47 IECC 303.1.1.1
48 ASTM C1015 - 06
<table>
<thead>
<tr>
<th></th>
<th>Safety</th>
<th>Insulation will not be allowed on top of non-insulation contact (IC) rated can-light boxes or between a heat-generating appliance and a dam unless material is rated for contact with heat generating sources</th>
<th>Prevent a fire hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Onsite documentation</td>
<td>Documentation will be posted as required by federal specification 16CFR460</td>
<td>Post documentation onsite to allow verification</td>
</tr>
</tbody>
</table>

49 ASTM C1015 - 06  
50 16CFR460.17
Topic: Attic
Subtopic: Accessible Attic Floors

18) **Detail Name:** Batt Insulation Over Existing Insulation

**Desired Outcome:**
- Insulation controls heat transfer through vaulted ceiling

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Preparation</td>
<td>Existing insulation will be in contact with the air barrier prior to installing additional insulation on top</td>
<td>Ensure proper performance of insulation</td>
</tr>
<tr>
<td>2</td>
<td>Installation</td>
<td>If the top of the existing insulation is below the top of the framing, new batts will be installed parallel with framing members. If the top of the existing insulation is above the top of the framing, new batts will be installed perpendicular to framing members.</td>
<td>Ensure uniform depth of insulation in continuous contact with existing insulation. Eliminate voids and gaps</td>
</tr>
<tr>
<td>3</td>
<td>Insulation</td>
<td>Batts will be installed according to manufacturer specifications without gaps, voids, compressions, misalignments or wind intrusions. Insulation will be installed to prescribed R-value.</td>
<td>Insulate to prescribed R-value</td>
</tr>
</tbody>
</table>

51 ASTM C 1320-05 (09)  
52 ASTM C 1320-05 (09)  
53 ASTM C 1320-05 (09)
<table>
<thead>
<tr>
<th></th>
<th>4 Safety</th>
<th>Insulation will not be allowed on top of non-insulation contact (IC) rated can-light boxes or between a heat-generating appliance and a dam unless material is rated for contact with heat generating sources.</th>
<th>Prevent a fire hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 Occupant education</td>
<td>Documentation of material and R-value will be provided to occupant.</td>
<td>Provide occupant with documentation of installation</td>
</tr>
</tbody>
</table>

54 ASTM C1015 - 06  
55 16CFR460.17
Topic: Attic
Subtopic: Enclosed Attic Floors

19) Detail Name: Dense Pack Installation – Bonus Room Floor

Desired Outcome:
- A consistent thermal boundary between conditioned and unconditioned space controls the heat flow

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Air barrier</td>
<td>Existence of air barrier material in line with the knee walls will be installed or verified when dense packing 56 Air barrier material will not bend, sag or move once dense packed 57</td>
<td>Hold dense pack in place</td>
</tr>
</tbody>
</table>
| 2   | Fill floors   | Each cavity will be 100% filled to consistent density:  
- Cellulose material will be installed to a minimum density of 3.5 pounds per cubic foot  
- Loose fiber glass material will be installed and will be specifically approved for air flow resistance to a minimum density of 2.2 pounds per cubic foot  
The number of bags installed will be confirmed and will match the number | Eliminate voids and settling  
Minimize framing cavity air flows |

56 ASTM E1186 - 03(2009)  
57 ASTM C1015 - 06
|   |   | required on the coverage chart 58
Insulation will be verified to prevent visible air movement using chemical smoke at 50 Pascals of pressure difference 59 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Safety</td>
<td>Insulation will not be allowed on top of non-insulation contact (IC) rated can-light boxes or between a heat-generating appliance and a dam unless material is rated for contact with heat generating sources 60 Prevent a fire hazard</td>
</tr>
<tr>
<td>4</td>
<td>Onsite documentation</td>
<td>Documentation will be posted as required by federal specification 16CFR460 61 Post documentation onsite to allow verification</td>
</tr>
</tbody>
</table>

---

58 16CFR460.17  
59 ASTM E1186 - 03(2009)  
60 ASTM C1015 - 06  
61 16CFR460.17
### Topic: Attic
#### Subtopic: Enclosed Attic Floors

#### 20) Detail Name: Dense Pack Installation – Attic Storage Platform

**Desired Outcome:**
- Insulation reduces heat flow through floor and framing cavities inaccessible to other treatments

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fill floors</td>
<td>Each cavity will be 100% filled to consistent density:</td>
<td>Eliminate voids and settling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cellulose material will be installed to a minimum density of 3.5 pounds per cubic foot</td>
<td>Minimize framing cavity air flows</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Loose fiber glass material will be installed and will be specifically approved for air flow resistance to a minimum density of 2.2 pounds per cubic foot</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The number of bags installed will be confirmed and will match the number required on the coverage chart 62</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation will be verified to prevent visible air movement using chemical smoke at 50 Pascals of pressure difference 63</td>
<td></td>
</tr>
</tbody>
</table>

---

62 16CFR460.17  
63 ASTM E1186 - 03(2009)
<table>
<thead>
<tr>
<th></th>
<th>Safety</th>
<th>Insulation will not be allowed on top of non-insulation contact (IC) rated can-light boxes or between a heat-generating appliance and a dam unless material is rated for contact with heat generating sources (^{64})</th>
<th>Prevent a fire hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Onsite documentation</td>
<td>Documentation will be posted as required by federal specification 16CFR460 (^{65})</td>
<td>Post documentation onsite to allow verification</td>
</tr>
</tbody>
</table>

\(^{64}\) ASTM C1015 - 06  
\(^{65}\) 16CFR460.17
### Topic: Attic

**Subtopic:** Attic Openings

---

**21) Detail Name:** Pull Down Stairs

**Desired Outcome:**
- Pull down attic stair properly sealed and insulated

---

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Installation</strong></td>
<td>Entire pull down stair assembly will be covered to the same R-Value as adjoining insulated assembly</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td>2</td>
<td><strong>Sealing</strong></td>
<td>Pull down stair frame will be continuously weather stripped</td>
<td>Prevent air leakage$^{66}$</td>
</tr>
<tr>
<td>3</td>
<td><strong>Durability</strong></td>
<td>Material integrity will meet a minimum expected service life of 20 years</td>
<td>Ensure a minimum expected service life</td>
</tr>
<tr>
<td>4</td>
<td><strong>Occupant education</strong></td>
<td>Purpose of insulation will be communicated to occupant$^{67}$</td>
<td>Educate occupant on how to use the hatch to ensure integrity of insulated assembly throughout service life</td>
</tr>
</tbody>
</table>

---

$^{66}$ ASTM E1186 - 03(2009)

$^{67}$ 16CFR460.17
**Topic: Attic**

**Subtopic: Attic Openings**

22) **Detail Name:** Access Doors and Hatches

**Desired Outcome:**
- Attic access door properly sealed and insulated

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Installation</td>
<td>Access hatches will be insulated to the same R-Value as adjoining insulated assembly</td>
<td>Achieve uniform R-value</td>
</tr>
<tr>
<td>2</td>
<td>Sealing</td>
<td>Access hatch frames will be continuously weather stripped</td>
<td>Prevent air leakage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A latch or lock will be installed to ensure hatch remains closed</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Attachment</td>
<td>Insulation will be permanently attached in complete contact with the access hatch</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td>4</td>
<td>Durability</td>
<td>Material integrity will meet a minimum expected service life of 20 years</td>
<td>Ensure a minimum expected service life</td>
</tr>
<tr>
<td>5</td>
<td>Occupant education</td>
<td>Purpose of insulation will be communicated to occupant</td>
<td>Educate occupant on how to use the hatch to ensure integrity of insulated assembly throughout service life</td>
</tr>
</tbody>
</table>

68 ASTM E1186 - 03(2009)
69 16CFR460.17
**Topic: Attic**  
**Subtopic: Attic Openings**

23) **Detail Name:** Whole-House Fan

**Desired Outcome:**
- Consistent, uniform thermal boundary between the conditioned space and unconditioned space to prescribed R-value of an adjoining insulated assembly

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Installation</td>
<td>Sides of fan insulation box assembly will be insulated to the same R-Value as adjoining insulated assembly</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td>2</td>
<td>Air sealing</td>
<td>Fan insulation box frame will be continuously weather stripped to ensure a tight fit</td>
<td>Prevent air leakage 70</td>
</tr>
<tr>
<td>3</td>
<td>Attachment</td>
<td>Insulation will be permanently attached in contact with fan insulation box</td>
<td>Ensure continuous alignment with air barrier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Appropriate adhesive or mechanical fastener will be used</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Durability</td>
<td>Material integrity will meet a minimum expected service life of 20 years</td>
<td>Ensure a minimum expected service life</td>
</tr>
<tr>
<td>5</td>
<td>Occupant education</td>
<td>Purpose of insulation will be communicated to occupant 71</td>
<td>Educate occupant on how to use the whole house fan to ensure integrity of the fan insulated assembly throughout service life</td>
</tr>
</tbody>
</table>

70 ASTM E1186 - 03(2009)  
71 16CFR460.17
**Topic: Attic**  
**Subtopic: Attics General**

24) **Detail Name:** Ventilation

**Desired Outcome:**
- Properly restored vents minimize moisture and ice dams

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Air barrier and thermal boundary</td>
<td>Attic ventilation will be recommended or installed only if:</td>
<td>Ensure presence of continuous air barrier and thermal boundary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The presence of an effective air barrier and thermal boundary between the attic and the living space is verified</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Appropriate attic sealing and proper insulation is specified as part of the work scope</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Vent type</td>
<td>Attic vent types will be consistent with requirements for their specific location (e.g., exterior soffit, gable end, roof) and material and intended use (e.g., metal vent on metal roof)</td>
<td>Vent meets proper performance characteristics for location and roofing type</td>
</tr>
<tr>
<td>3</td>
<td>Vent location</td>
<td>Placement of attic vents will be considered for proper air flow and prevention of entry of wind-driven rain or snow</td>
<td>Encourage proper air flow and minimize entry of wind-driven rain or snow</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
</tbody>
</table>
| 4 | Ventilation baffling | Baffling for attic vents will be installed to:  
• Ensure proper air flow  
• Prevent wind-washing of insulation  
• Allow maximum insulation coverage  
• Ensure baffle terminates above insulation | Vent allows proper air flow without compromising insulation performance |
| 5 | Ventilation screens | All attic ventilation will have screens with non-corroding wire mesh with openings of ” to prevent pest entry (e.g., birds, bats, bees)  
Existing vents which are not screened will be covered with non-corroding wire mesh with openings of ” | Prevent pest entry |
**Topic:** Attic  
**Subtopic:** Attics General

25) **Detail Name:** Radiant Barrier

**desired outcome:**
- Radiant heat flow reduced

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Stapling</strong></td>
<td>An air space no less than ¾” will be maintained between the barrier and the bottom of the roof deck</td>
<td>Ensure performance of radiant barrier</td>
</tr>
<tr>
<td>2</td>
<td><strong>Ventilation</strong></td>
<td>A minimum of 3” clearance from soffit vents and ridge vents will be maintained</td>
<td>Allow for air flow behind barrier</td>
</tr>
<tr>
<td>3</td>
<td><strong>Gable walls</strong></td>
<td>Radiant barrier will apply to gable walls while maintaining a ¾” air space</td>
<td>Ensure performance of radiant barrier</td>
</tr>
</tbody>
</table>
| 4   | **Porch and garage attic spaces** | Radiant barrier will be installed to separate the attic above conditioned space from adjacent attics  
Radiant barrier will be installed to withstand local wind loads | Ensure reduction of radiant heat entry  
Durability |

**Topic: Attic**

**Subtopic:** Attics General

26) **Detail Name:** Skylights

**Desired Outcome:**
- Consistent uniform thermal boundary between the conditioned space and unconditioned space to prescribed R-value

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sealing</td>
<td>Holes and penetrations will be sealed</td>
<td>Prevent air leakage 73</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bypasses will be blocked and sealed 72</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Installation</td>
<td>Insulation will be installed according to manufacturer specifications in full contact with all sides of existing cavity without gaps, voids, compressions, misalignments or wind intrusions 74</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation will be installed to prescribed R-value</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td>3</td>
<td>Occupant education</td>
<td>Documentation of material and R-value will be provided to occupant 75</td>
<td>Provide occupant with documentation of installation</td>
</tr>
</tbody>
</table>

72 ASTM E1186 - 03(2009)  
73 ASTM E1186 - 03(2009)  
74 ASTM C1015 - 06  
75 16CFR460.17
Topic: Attic
Subtopic: Attics General

27) Detail Name: Parapet Walls

Desired Outcome:
- Properly installed insulation reduces heat flow through parapet wall

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Access</td>
<td>Proper access in wall exterior or interior containment area will be ensured</td>
<td>Protect worker and occupant health</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lead safety procedures in houses built before 1978 will be followed 76</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Installation</td>
<td>Dense pack insulation will be installed according to manufacturer specifications at void area 77</td>
<td>Seal wall</td>
</tr>
</tbody>
</table>

76 OSHA Publication 3142-09R
77 ASTM C1015 - 06
Exterior Walls

Preparation:
   28) Dense Pack Preparation

Accessible Exterior Walls:
   29) Open Wall Insulation

Enclosed Exterior Walls:
   30) Dense Pack Exterior Walls
   31) Additional Exterior Wall Cavities
Topic: Exterior Walls
Subtopic: Preparation

28) Detail Name: Exterior Dense Pack

Desired Outcome:
• Walls properly prepared to receive dense pack insulation

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Preparation 78</td>
<td>Lead safety procedures will be followed 79</td>
<td>Prevent damage to house and mess</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cavities will be free of hazards, intact and able to support dense pack pressures</td>
<td>Provide thorough access to allow 100% coverage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drilling hazards (e.g., wiring, venting, fuel piping) will be located</td>
<td>Ensure proper equipment and process results in consistent density</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blocking will be installed around:</td>
<td>preventing settling and retarding air flow through cavities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• All openings to inside crawl space and basement for fibrous material</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• High-temperature fire-rated materials</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Wiring and electrical hazards</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Heat sources</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Access to exterior wall cavities will be gained, sheathing will be drilled as</td>
<td></td>
</tr>
</tbody>
</table>

78 ASTM C1015 - 06
79 OSHA 3142-09R, 2003
|   |   | needed and probed to locate each cavity, wall studs and blockers  
Interior will be masked and dust controlled during drilling when accessing from interior  
Electricity supply will be confirmed and will support blowing machine power demand  
Blowing machine pressure test will be performed with air on full, feed off and gate closed  
Hose outlet pressure will be at least 80 inches of water column (IWC) or 2.9 pounds per square inch (PSI)  
Using fill tube, 100% of each cavity will be completely filled to a consistent density:  
- Cellulose material will be installed to a minimum density of 3.5 pounds per cubic foot  
- Loose fiber glass material will be installed and will be specifically approved for air flow resistance to a minimum density of 2.2 pounds per cubic foot  
The number of bags installed will be confirmed and will match the number required on the coverage  
| 2 | Exterior dense pack |   |   | Eliminate voids and settling  
Minimize framing cavity air flows |
| chart ⁸⁰  
| Insulation will be verified to prevent visible air movement using chemical smoke at 50 Pascals of pressure difference ⁸¹ |

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⁸⁰ 16CFR460.17  
⁸¹ ASTM E1186 - 03(2009)
## Topic: Exterior Walls
### Subtopic: Accessible Exterior Walls

**29) Detail Name:** Open Wall Insulation

**Desired Outcome:**
- Consistent, uniform thermal boundary between the conditioned space and unconditioned space to prescribed R-value

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sealing</td>
<td>Holes and penetrations will be sealed</td>
<td>Prevent air leakage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bypasses will be blocked and sealed</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Installation</td>
<td>Insulation will be installed according to manufacturer specifications without gaps, voids, compressions, misalignments or wind intrusions</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation will be installed to prescribed R-value</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Pre-drywall verification</td>
<td>Verification of complete installation without gaps, voids, compressions, misalignments or wind intrusions will be provided</td>
<td>Install insulation correctly</td>
</tr>
<tr>
<td>5</td>
<td>Occupant education</td>
<td>Documentation of material and R-value will be provided to occupant</td>
<td>Provide occupant with documentation of installation</td>
</tr>
</tbody>
</table>

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82 ASTM E1186 - 03(2009)
83 ASTM E1186 - 03(2009)
84 ASTM C1015 - 06
85 ASTM C 1320-05 (09)
86 16CFR460.17
### Topic: Exterior Walls

**Subtopic:** Enclosed Exterior Walls

#### 30) Detail Name: Dense Pack Exterior Walls

**Desired Outcome:**
- Consistent, uniform thermal boundary between conditioned and unconditioned space to prescribed R-value of an adjoining insulated assembly

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Exterior dense pack</td>
<td>Using fill tube, 100% of each cavity will be completely filled to a consistent density:</td>
<td>Eliminate voids and settling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cellulose material will be installed to a minimum density of 3.5 pounds per cubic foot</td>
<td>Minimize framing cavity air flows</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Loose fiber glass material will be installed and will be specifically approved for air flow resistance to a minimum density of 2.2 pounds per cubic foot</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The number of bags installed will be confirmed and will match the number required on the coverage chart</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation will be verified to prevent visible air movement using chemical smoke at 50 Pascals of pressure difference</td>
<td></td>
</tr>
</tbody>
</table>

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87 16CFR460.17  
88 ASTM E1186 - 03(2009)
**Topic: Exterior Walls**  
**Subtopic:** Enclosed Exterior Walls

### 31) Detail Name: Additional Exterior Wall Cavities

**Desired Outcome:**
- Properly installed insulation reduces heat flow through walls and framing cavities inaccessible to other treatments

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Location of cavities</td>
<td>Details remaining in or between completed wall sections will be located and accessed</td>
<td>Ensure the last gaps and framing edges in the thermal boundary, roof-wall joints, floor-wall joints, etc. are found and finished</td>
</tr>
<tr>
<td>2</td>
<td>Sealing</td>
<td>Backing will be provided and all newly uncovered openings will be sealed with air barriers, foam or mastic, maintaining all required clearances</td>
<td>Ensure the air barrier is connected across all accessible house elements</td>
</tr>
</tbody>
</table>
| 3   | Dense packing          | Using fill tube, 100% of each cavity will be completely filled to a consistent density:  
  - Cellulose material will be installed to a minimum density of 3.5 pounds per cubic foot  
  - Loose fiber glass material will be installed and will be specifically approved for air flow resistance to a minimum density of 2.2 pounds per cubic foot | Eliminate voids and settling  
  Minimize framing cavity air flows  
  The number of bags installed will be confirmed and will match the number |

---

**DRAFT FOR PUBLIC REVIEW**
<table>
<thead>
<tr>
<th>Quality assurance</th>
<th>Close holes</th>
</tr>
</thead>
</table>

4 Required on the coverage chart. Insulation will be verified to prevent visible air movement using chemical smoke at 50 Pascals of pressure difference.

Completed wall sections will be viewed using infrared camera with blower door operating. Any voids or low density areas will be drilled and repacked. Installation holes will be repaired and sealed. All construction debris and dust will be collected and removed.

Establish air barrier and thermal boundary. Confirm no voids or hidden air flows remain. Ensure house is returned to watertight and clean condition.

Installation holes will be plugged as follows:

- Exterior holes will be weather barrier patched
- Interior holes will be rough coated and patched

Ensure house is returned to watertight and clean condition.

All construction debris and dust will be collected and removed.

---

89 16CFR460.17
90 ASTM E1186 - 03(2009)
91 ASTM E1186 - 03(2009)
Floors

Accessible Floors:

32) Batt Installation Floor System
33) Loose Fill Floor System with Netting
34) Loose Fill Floor System with Rigid Barrier
35) Batt Installation Cantilevered Floor
36) Pier house subfloor insulation – Batt installation with rigid barrier
37) Pier house subfloor insulation – loose fill with rigid barrier
Topic: Floors
Subtopic: Accessible Floors

32) Detail Name: Batt Installation Floor System

Desired Outcome:
- Consistent, uniform thermal boundary between conditioned and unconditioned space to prescribed R-value of an adjoining insulated assembly

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sealing</td>
<td>Sealing the floor system will be completed before insulating</td>
<td>Ensure airtight envelope</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Prevent leakage</td>
</tr>
<tr>
<td>2</td>
<td>Installation</td>
<td>Insulation will be installed in contact with subfloor without gaps, voids,</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>compressions, misalignments or wind intrusions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>If kraft faced batts are used, they will be installed with kraft-facing to</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>subfloor</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation will be installed to prescribed R-value</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Securing batts</td>
<td>Batts will be secured with physical fasteners</td>
<td>Ensure insulation remains in contact with subfloor</td>
</tr>
<tr>
<td>4</td>
<td>Occupant education</td>
<td>Documentation of material and R-value will be provided to occupant</td>
<td>Provide occupant with documentation of installation</td>
</tr>
</tbody>
</table>

92 ASTM C 1320-05 (09)
93 ASTM C 1320-05 (09)
94 16CFR460.17
**Topic: Floors**  
**Subtopic: Accessible Floors**

**33) Detail Name:** Loose Fill Floor System with Netting

**Desired Outcome:**
- Consistent, uniform thermal boundary between conditioned and unconditioned space to prescribed R-value of an adjoining insulated assembly

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Sealing                | Sealing the floor system will be completed before insulating ⁹⁵                  | Ensure airtight envelope  
Prevent leakage                                                                 |
| 2   | Netting, fabric        | When using netting or fabric, staples will be placed every 1 ½” on center       | Secure insulation in place                                                  |
|     |                        | Netting or fabric will meet local fire codes ⁹⁶                                 |                                                                              |
| 3   | Installation           | Insulation in netted or fabric cavities will be dense packed with loose fill insulation according to manufacturer specifications ⁹⁷ | Insulate to prescribed R-value  
Ensure a continuous thermal boundary between conditioned and unconditioned space |
|     |                        | Insulation will be installed to prescribed R-value                              |                                                                              |
|     |                        | Insulation will be in continuous contact with air barrier                      |                                                                              |
| 4   | Occupant education     | Documentation of material and R-value will be provided to occupant ⁹⁸           | Provide occupant with documentation of installation                         |

⁹⁵ ASTM E1186 - 03(2009)  
⁹⁶ ASTM E84 - 10  
⁹⁷ ASTM C1015 - 06  
⁹⁸ 16CFR460.17
**Topic: Floors**

**Subtopic: Accessible Floors**

**34) Detail Name:** Loose Fill Floor System with Rigid Barrier

**Desired Outcome:**
- Consistent uniform thermal boundary between conditioned and unconditioned space to prescribed R-value of an adjoining insulated assembly

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sealing</td>
<td>Sealing the floor system will be completed before insulating&lt;sup&gt;99&lt;/sup&gt;</td>
<td>Ensure airtight envelope</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Prevent leakage</td>
</tr>
<tr>
<td>2</td>
<td>Rigid air barrier</td>
<td>A rigid air barrier will be mechanically fastened to underside of floor assembly</td>
<td>Relocate air barrier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seams and penetrations will be sealed</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Installation</td>
<td>Loose fill insulation will be installed between air barrier and subfloor according to manufacturer specifications&lt;sup&gt;100&lt;/sup&gt;</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation will be installed to prescribed R-value</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Occupant education</td>
<td>Documentation of material and R-value will be provided to occupant&lt;sup&gt;101&lt;/sup&gt;</td>
<td>Provide occupant with documentation of installation</td>
</tr>
</tbody>
</table>

<sup>99</sup> ASTM E1186 - 03(2009)
<sup>100</sup> ASTM C1015 - 06
<sup>101</sup> 16CFR460.17
**Topic: Floors**

**Subtopic: Accessible Floors**

35) **Detail Name:** Batt Insulation Cantilevered Floor

**Desired Outcome:**
- Consistent, uniform thermal boundary between conditioned and unconditioned space to prescribed R-value of an adjoining insulated assembly

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Air barrier</td>
<td>Air barrier will be installed between joists and sealed</td>
<td>Separate cantilevered floor from conditioned floor space</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air barrier will be placed to the most interior edge of the top plate of the wall below</td>
<td>Allow for insulation</td>
</tr>
<tr>
<td>2</td>
<td>Installation</td>
<td>Air barrier will be insulated between joist from top plate of the wall below to subfloor above</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cantilevered subfloor will be insulated in complete contact with the floor without gaps, voids, compressions, misalignments or wind intrusions 102</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>If kraft-faced batts are used, they will be installed with kraft-facing to the air barrier</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation will be installed to prescribed R-value</td>
<td></td>
</tr>
</tbody>
</table>

102 ASTM C 1320-05 (09)
<table>
<thead>
<tr>
<th></th>
<th>Attachment</th>
<th>Batts will be secured with physical fasteners 103</th>
<th>Ensure insulation remains in contact with subfloor and air barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Exterior soffit</td>
<td>Exterior soffit material will be installed and sealed</td>
<td>Cover and protect insulation</td>
</tr>
<tr>
<td>5</td>
<td>Occupant education</td>
<td>Documentation of material and R-value will be provided to occupant 104</td>
<td>Provide occupant with documentation of installation</td>
</tr>
</tbody>
</table>

103 ASTM C 1320-05 (09)
104 16CFR460.17
### Topic: Floors  
**Subtopic:** Accessible Floors

#### 36) Detail Name: Pier house subfloor insulation – Batt installation with rigid barrier

**Desired Outcome:**
- Consistent, uniform thermal barrier between conditioned and unconditioned space to prescribed R-value of an adjoining insulated assembly

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Subfloor preparation</td>
<td>Sealing between house and crawl space will be completed before insulating</td>
<td>Ensure airtight envelope</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Prevent leakage</td>
</tr>
<tr>
<td>2</td>
<td>Installation</td>
<td>Insulation will be installed in contact with subfloor without gaps, voids,</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>compressions, misalignments or wind intrusions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>If kraft faced batts are used, they will be installed with kraft-facing to</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>subfloor</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation will be installed to prescribed R-value</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Secure batts</td>
<td>Batts will be secured with physical fasteners</td>
<td>Ensure insulation remains in contact</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>with subfloor</td>
</tr>
<tr>
<td>4</td>
<td>Rigid air barrier</td>
<td>A rigid air barrier will be mechanically fastened to underside of floor assembly</td>
<td>Protect Insulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seams and penetrations will be sealed</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Occupant education</td>
<td>Documentation of material and R-value will be provided to occupant</td>
<td>Provide occupant with documentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>of installation</td>
</tr>
</tbody>
</table>
**Topic: Floors**

**Subtopic: Accessible Floors**

37) **Detail Name:** Pier house subfloor insulation – loose fill with rigid barrier

**Desired Outcome:**
- Consistent, uniform thermal barrier between conditioned and unconditioned space to prescribed R-value of an adjoining insulated assembly

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Subfloor preparation</td>
<td>Sealing between house and crawl space will be completed before insulating</td>
<td>Prevent air leakage</td>
</tr>
<tr>
<td>2</td>
<td>Rigid air barrier</td>
<td>A rigid air barrier will be mechanically fastened to underside of floor assembly</td>
<td>Relocate air barrier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seams and penetrations will be sealed</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Installation</td>
<td>Loose fill insulation will be installed between air barrier and subfloor according to manufacturer specifications</td>
<td>Insulate to prescribed R-value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation will be installed to prescribed R-value</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Occupant education</td>
<td>Documentation of material and R-value will be provided to occupant</td>
<td>Provide occupant with documentation of installation</td>
</tr>
</tbody>
</table>
SECTION 7: CRAWL SPACES AND BASEMENTS

Table of Contents

Health and Safety

Safe Work Practices: ¹
1) Crawl Space and Basement Worker Safety
2) Combustion Safety
3) Material Selection, Labeling and Material Safety Data Sheets (MSDS)

Separation of Basements and Crawl Spaces:
4) Basements Connected to Crawl Spaces

Crawl Space Health and Safety:
5) Radon
6) Access
7) Crawl Space Information Sign
8) Occupant Education
9) Return and Supply Plenums
10) Warranty and Service Agreement

Basement Health and Safety:
11) Knob and Tube Wiring

Crawl Spaces

Site Preparation:
12) Pre-Work Qualifications
13) Debris Removal
14) Drainage
15) Preliminary Dehumidification
16) Negative Pressure Contamination Control
17) Sealing Floor Penetrations
18) Regional Considerations

Vented Crawl Spaces:
19) Ground Moisture Barrier

¹ Appendix D – OSHA Personal Protective Equipment Standards
20) Venting

**Closed Crawl Spaces:**
- 21) Skirting on Post and Pier Foundations
- 22) Air Sealing the Foundation Vents
- 23) Air Sealing the Exterior Wall
- 24) Air Sealing Brick Curtain Wall with Piers
- 25) Vapor Retarders on Walls
- 26) Attached Crawl Spaces Under Unconditioned Spaces
- 27) Wall Insulation
- 28) Ground Moisture Barrier
- 29) Crawl Space Conditioning
- 30) Regional Considerations

**Basements**

**Insulation and Conditioning:**
- 31) Basement Wall Insulation – No Ground Water Leakage
- 32) Basement Wall Insulation – Ground Water Leakage
- 33) Dehumidification
Health and Safety

Safe Work Practices:
1) Crawl Space and Basement Worker Safety
2) Combustion Safety
3) Material Selection, Labeling and Material Safety Data Sheets (MSDS)

Separation of Basements and Crawl Spaces:
4) Basements Connected to Crawl Spaces

Crawl Space Health and Safety:
5) Radon
6) Access
7) Crawl Space Information Sign
8) Occupant Education
9) Return and Supply Plenums
10) Service Agreement and Warranty

Basement Health and Safety:
11) Knob and Tube Wiring
**Topic: Health and Safety**

**Subtopic: Safe Work Practices**

1) **Detail Name:** Crawl Space and Basement Worker Safety

**Desired Outcome:**
- Work completed safely without injury or hazardous exposure

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hand protection</td>
<td>Durable gloves will be worn that will withstand work activity</td>
<td>Minimize skin contact with contaminants</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Protect hands from sharp objects</td>
</tr>
<tr>
<td>2</td>
<td>Respiratory protection</td>
<td>Respirators appropriate for the contaminants present will be worn (e.g. N-95 or equivalent face mask) ²</td>
<td>Minimize exposure to airborne contaminants (e.g. insulation materials, mold spores, feces, bacteria, chemicals)</td>
</tr>
<tr>
<td>3</td>
<td>Electrical safety ³,⁴</td>
<td>An electrical safety assessment will be performed</td>
<td>Avoid electrical shock and arc flash hazards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All electric tools will be protected by Ground-Fault Circuit Interrupters ⁵</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Extension cords used with portable electric tools will be of three-wire type</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Worn or frayed electric cords will not be used</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water such as condensate pans and electrical sources will be kept separate</td>
<td></td>
</tr>
</tbody>
</table>

² OSHA Technical Manual Section VIII: Chapter 2, section IV
⁴ 29 CFR 1926 Subpart K – Electrical
<table>
<thead>
<tr>
<th></th>
<th>Table Title</th>
<th>Description</th>
<th>Precaution</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Protective clothing</td>
<td>If contaminants are present, (e.g. feces, chemicals) removable protective clothing will be worn. Eye protection will be worn at all times (e.g. safety glasses, goggles if not using full face respirator).</td>
<td>Protect worker from skin contact with contaminants. Minimize spread of contaminants.</td>
</tr>
<tr>
<td>5</td>
<td>Confined space safety</td>
<td>Access and egress points will be located before beginning work. Inspection will be conducted for frayed electrical wires. Adequate ventilation will be provided. Use of toxic material will be reduced.</td>
<td>Prevent build-up of toxic or flammable contaminants. Provide adequate access and egress. Avoid electrical shock.</td>
</tr>
<tr>
<td>6</td>
<td>Power tool safety</td>
<td>Power tools will be inspected and used according to manufacturer specifications to eliminate hazards associated with missing ground prongs, ungrounded circuits, misuse of power tools, noise and improper or defective cords or extension cords. All devices used will be verified as GFI protected or double insulated. Exhaust gases from compressors and generators.</td>
<td>Prevent power tool injuries.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td></td>
<td>will be prevented from entering crawl space</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Chemical safety</td>
<td>The least toxic suitable material will be chosen</td>
<td>Prevent worker exposure to toxic substances</td>
</tr>
<tr>
<td>8</td>
<td>Ergonomic safety</td>
<td>Personal Protective Equipment will be used (e.g. knee pads, bump caps, additional padding)</td>
<td>Avoid injuries with awkward postures and repetitive motions</td>
</tr>
<tr>
<td>9</td>
<td>Hand tool safety</td>
<td>Hand tools will be used for intended purpose</td>
<td>Reduce injuries</td>
</tr>
<tr>
<td>10</td>
<td>Slips, trips and falls</td>
<td>Caution will be used around power cords, hoses, tarps and plastic sheeting</td>
<td>Eliminate injuries due to slips, trips and falls</td>
</tr>
<tr>
<td>11</td>
<td>Prevention through design</td>
<td>Design will be incorporated to eliminate or minimize hazards (e.g. material selection, access to equipment for installation and maintenance, placement of equipment, duct work and condensate lines)</td>
<td>Prevent worker injuries, exposure to toxic substances and physical hazards</td>
</tr>
</tbody>
</table>

10 Appendix D – OSHA Personal Protective Equipment Standards
11 29 CFR 1910 Subpart Z - Toxic and Hazardous Substances
13 29 CFR 1910 Subpart P - Hand and portable powered tools and other hand-held equipment
14 29 CFR 1926 Subpart M - Fall Protection
15 29 CFR 1926 Subpart C - General Safety and Health Provisions
**Topic: Health and Safety**  
**Subtopic: Safe Work Practices**

2) **Detail Name:** Combustion Safety

**Desired Outcome:**
- Buildup of dangerous combustion byproducts in the living space prevented

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Outside combustion makeup air</td>
<td>Combustion air for fuel-burning appliances will be supplied from outside</td>
<td>Prevent combustion byproducts from entering the house</td>
</tr>
<tr>
<td>2</td>
<td>New appliances</td>
<td>If replacing appliances, a sealed-combustion, direct-vent appliance will be installed</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Carbon monoxide (CO) monitor and alarm</td>
<td>A CO alarm will be installed that displays real-time CO levels inside of the living space</td>
<td>Alert occupant to CO exposure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Device will be installed according to manufacturer specifications</td>
<td></td>
</tr>
</tbody>
</table>
Topic: Health and Safety
Subtopic: Safe Work Practices

3) **Detail Name:** Material Selection, Labeling and Material Safety Data Sheets (MSDS)

**Desired Outcome:**
- Occupant and worker risk from hazardous materials minimized

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Material selection</td>
<td>Materials that do not create long-term health risks for occupants and workers will be used</td>
<td>Improve indoor air quality in the living space</td>
</tr>
<tr>
<td>2</td>
<td>Material labels</td>
<td>Manufacturer specifications will be followed</td>
<td>Reduce risk of exposure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Follow safety procedures</td>
</tr>
<tr>
<td>3</td>
<td>Material Safety Data Sheets (MSDS)</td>
<td>MSDS will be provided on site and available during all work</td>
<td>Assess exposure risk and prepare a response in case of emergency</td>
</tr>
</tbody>
</table>
**Topic: Health and Safety**

**Subtopic:** Separation of Basements and Crawl Spaces

4) **Detail Name:** Basements Connected to Crawl Spaces*

**Desired Outcome:**
- Crawl spaces and basements are separated using appropriate methods that define spaces and allow for treatment according to specifications

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conditioned basements with vented crawl spaces</td>
<td>Crawl space will be separated from the conditioned basement with a continuous air barrier, ground moisture barrier and thermal boundary*</td>
<td>Create separation and define spaces</td>
</tr>
<tr>
<td>2</td>
<td>Conditioned basements with closed crawl spaces</td>
<td>Crawl space will be separated from the conditioned basement with a continuous air barrier and ground moisture barrier*</td>
<td>Enable treatment of crawl spaces and basements by referenced specifications</td>
</tr>
<tr>
<td>3</td>
<td>Unconditioned basements with vented crawl spaces</td>
<td>Vented crawl space will be separated from the unconditioned basement with a continuous air barrier and ground moisture barrier*</td>
<td>Increase house durability and energy efficiency</td>
</tr>
<tr>
<td>4</td>
<td>Unconditioned basements with closed crawl spaces</td>
<td>Unconditioned basement will be treated as an extension of the closed crawl space*</td>
<td></td>
</tr>
</tbody>
</table>

*Follow specifications for conditioned/unconditioned basements and vented/closed crawl spaces*
Topic: Health and Safety
Subtopic: Occupant Health

5) **Detail Name:** Radon

**Desired Outcome:**
- Work completed without increasing occupant exposure to radon

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objectives(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Radon Testing and Mitigation</td>
<td>EPA Guidelines for Radon in current edition of “Healthy Indoor Environment Protocols for Home Energy Retrofits” will be followed</td>
<td>Complete retrofit work without increasing occupant exposure to radon</td>
</tr>
</tbody>
</table>
**Topic: Health and Safety**  
**Subtopic:** Crawl Space Health and Safety

6) **Detail Name:** Access

**Desired Outcome:**
- Access to the closed crawl space is controlled and the ground moisture barrier is protected to maintain the integrity of the system

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
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</tr>
</thead>
</table>
| 1   | Access| Crawl space will be accessible for service and maintenance without risk of damage to the thermal and air barrier and ground moisture barrier | Provide crawl space access  
Maintain integrity of the crawl space system |
| 2   | Lock  | A lockable access will be provided if access is from the exterior | Control access and prevent intruders |
**Topic: Health and Safety**

**Subtopic: Crawl Space Health and Safety**

7) **Detail Name:** Crawl Space Information Sign

**Desired Outcome:**
- Posted signs inside of the crawl space provide essential safety and maintenance information to occupant and users of the crawl space

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
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</tr>
</thead>
</table>
| 1   | Sign specifications | A durable, easily seen sign will be installed at all accesses inside of the crawl space (minimum 8 ½” x 11”)
     |                   | A minimum expected service life of 10 years will be ensured ¹⁶                   | Prevent damage to the crawl space after retrofit |
| 2   | Sign content      | Those entering the crawl space will be cautioned not to damage the air barrier, ground moisture barrier, insulation and mechanical components specific to the crawl space type
     |                   | Anyone entering the crawl space will be alerted that immediate repairs are needed in case of damage
     |                   | The installer’s contact information will be included on the sign in case there are questions or needs for repairs | Prevent damage to the crawl space after retrofit
     |                   |                                                                                   | Educate anyone entering the crawl space          |
     |                   |                                                                                   | Provide occupants with a way to contact the installer |
| 3   | Hazard warning    | Language prohibiting storage of hazards and flammable materials will be provided on site | Prevent storage of hazardous or flammable materials in the crawl space
     |                   |                                                                                   | Maintain indoor air quality                        |

¹⁶ ASTM C1136 - 10
Prevent a fire hazard
# Topic: Health and Safety

**Subtopic: Crawl Space Health and Safety**

8) **Detail Name:** Occupant Education

**Desired Outcome:**
- Occupants educated on the crawl space system and how to maintain it

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Written communication</td>
<td>Occupants will be given written documentation that describes components of the system, maintenance requirements, and health and safety considerations at a minimum. Information will be provided in simple terms. Text and pictures will be used. Documentation may be provided electronically.</td>
<td>Provide occupant with a basic understanding and documentation of the system, its maintenance and related health and safety issues.</td>
</tr>
<tr>
<td>2</td>
<td>Oral communication</td>
<td>When possible, the written documents will be reviewed with the occupants.</td>
<td>Confirm that occupants have received the information. Provide an opportunity for questions and answers.</td>
</tr>
<tr>
<td>3</td>
<td>Contact information</td>
<td>Information about the installation company and warranty will be provided.</td>
<td>Provide occupants with a way to contact the installer.</td>
</tr>
</tbody>
</table>
## Topic: Health and Safety  
**Subtopic:** Crawl Space Health and Safety

9) **Detail Name:** Return and Supply Plenums

**Desired Outcome:**
- Connections between the crawl space and living space eliminated to improve indoor air quality (IAQ) and efficiency of the distribution system

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Supply plenums (includes conditioned crawl spaces) | Crawl spaces that are used as heating and cooling supply plenums will not be allowed | Improve IAQ in the living space  
Eliminate connection between the crawl space and living space |
| 2   | Return plenums                             |                                                                                  | Achieve energy impacts                           |
### Topic: Health and Safety

**Subtopic:** Crawl Space Health and Safety

10) **Detail Name:** Warranty and Service Agreement

**Desired Outcome:**
- Occupants provided recourse for failures in materials, workmanship and serviceability and informed of potential hazards

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Warranty</td>
<td>A minimum one-year warranty for materials, workmanship and serviceability will be provided. The warranty will be provided to occupants before work.</td>
<td>Provide recourse to occupants for failures in materials, workmanship and serviceability.</td>
</tr>
<tr>
<td>2</td>
<td>Warranty renewal and service agreement</td>
<td>An option for annual inspection and renewal of warranty and service agreement for up to 10 years will be offered at a cost (requirement for installers).</td>
<td>Provide occupants with an option for extending the warranty and service agreement.</td>
</tr>
<tr>
<td>3</td>
<td>General conditions</td>
<td>At a minimum, the following concerns and warnings will be addressed within the warranty: possible drying and shrinking effects; storage of hazardous and flammable materials; mold.</td>
<td>Educate occupants on potential hazards.</td>
</tr>
</tbody>
</table>
**Topic: Health and Safety**

**Subtopic: Basement Health and Safety**

11) **Detail Name:** Knob and Tube Wiring

**Desired Outcome:**
- Live unsafe wiring identified and brought to local codes

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knob and tube identification</td>
<td>The house will be visually inspected</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Live wire testing</td>
<td>Noncontact testing method will be used to determine if wiring is live</td>
<td>Protect occupant safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Preserve the integrity and safety of the house</td>
</tr>
<tr>
<td>3</td>
<td>Isolation and protection</td>
<td>Live knob and tube will not be covered or surrounded</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A dam that does not cover the top will be created to separate insulation from the wire path</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Replacement</td>
<td>Exposed wiring will be replaced with new appropriate wiring and old wiring rendered inoperable by licensed electrician according to local codes</td>
<td></td>
</tr>
</tbody>
</table>
Crawl Spaces

Site Preparation:
12) Pre-Work Qualifications
13) Debris Removal
14) Drainage
15) Preliminary Dehumidification
16) Negative Pressure Contamination Control
17) Sealing Floor Penetrations
18) Regional Considerations

Vented Crawl Spaces:
19) Ground Moisture Barrier
20) Venting
21) Floor Insulation – Batts
22) Floor Insulation – Loose Fill with Netting or Fabric
23) Floor Insulation – Loose Fill with Rigid Air Barrier beneath floor assembly

Closed Crawl Spaces:
24) Skirting on Post and Pier Foundations
25) Air Sealing the Foundation Vents
26) Air Sealing the Exterior Wall
27) Air Sealing Brick Curtain Wall with Piers
28) Vapor Retarders on Walls
29) Attached Crawl Spaces Under Unconditioned Spaces
30) Wall Insulation
31) Ground Moisture Barrier
32) Crawl Space Conditioning
33) Regional Considerations
**Topic: Crawl Spaces**

**Subtopic: Site Preparation**

12) **Detail Name:** Pre-Work Qualifications

**Desired Outcome:**
- Site properly prepared for retrofit

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fuel leaks</td>
<td>Fuel leaks will be repaired 17</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Electrical hazards</td>
<td>Electrical hazards will be eliminated 18</td>
<td>Ensure site is safe and ready for retrofit</td>
</tr>
<tr>
<td>3</td>
<td>Mold</td>
<td>Appropriate remediation will be completed before retrofit 19</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Combustion appliances</td>
<td>Needs for combustion appliances will be addressed as prescribed by local codes</td>
<td>Prepare site for retrofit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and Building Performance Institute (BPI) or equivalent combustion safety protocol 20</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Plumbing and water leaks</td>
<td>Plumbing leaks will be repaired before crawl space retrofit 21</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Pest and termite work</td>
<td>Pest and termite treatment will be completed before crawl space retrofit</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Structural repairs, modifications</td>
<td>Structural repairs and modifications will be completed before retrofit 22</td>
<td></td>
</tr>
</tbody>
</table>

17 ASTM D4276 - 02(2007)
18 ASTM D4276 - 02(2007)
19 ASTM D4276 - 02(2007)
21 ASTM E241 -08
22 ASTM E241 -08
<table>
<thead>
<tr>
<th></th>
<th><strong>Appliance and heating, ventilation and air conditioning (HVAC) system repairs and change outs</strong></th>
<th><strong>Appliances and HVAC system repairs or change outs will be completed before retrofit</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td><strong>Correctable standing water</strong></td>
<td><strong>Passive drains or sump pumps will be used to remove standing water</strong> <strong>23</strong></td>
</tr>
<tr>
<td>10</td>
<td><strong>Non-correctable standing water</strong></td>
<td><strong>Spaces with non-correctable standing water should not be considered for a closed crawl space</strong> <strong>24</strong></td>
</tr>
</tbody>
</table>

23 ASTM E241 -08  
24 ASTM E241 -08
Topic: Crawl Spaces  
Subtopic: Site Preparation

13) Detail Name: Debris Removal  

Desired Outcome:  
- Clean, safe and easily accessible crawl space created

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Desired Outcome(s)</th>
</tr>
</thead>
</table>
| 1   | Debris removal    | All unnecessary material and debris greater than 1” will be removed from the crawl space (e.g., rake the crawl space) 25 | Minimize punctures in ground liner  
Minimize habitat for pests (Integrated Pest Management-IPM) and contaminant sources |
| 2   | Debris disposal   | Debris will be properly disposed of according to type and jurisdiction           | Protect environment from damage                                                  |

25 ASTM D4276 – 02(2007) section 5.3.3
### Topic: Crawl Spaces

**Subtopic:** Site Preparation

#### 14) Detail Name: Drainage

**Desired Outcome:**
- Water and conditions conducive to mold growth, wood rot and pests eliminated

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Exterior grading</td>
<td>Ground will be sloped away from the house ²⁶</td>
<td>Drain water away from the foundation wall</td>
</tr>
<tr>
<td>2</td>
<td>Roof drainage</td>
<td>If downspouts are present (e.g., gutters, overhangs, French drain), they will be drained a minimum of 6’ away from the house</td>
<td>Prevent roof water from leaking into the crawl space or basement</td>
</tr>
<tr>
<td>3</td>
<td>Exterior waterproofing</td>
<td>Foundation walls will be waterproof ²⁷</td>
<td>Prevent water from leaking into the crawl space or basement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exterior foundation drains will be installed ²⁸</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Interior grading</td>
<td>Interior grading will be sloped to one or more collection points if possible ²⁹</td>
<td>Collect interior water for removal</td>
</tr>
<tr>
<td>5</td>
<td>Interior drainage</td>
<td>One or more drains or sump pumps will be installed ³⁰</td>
<td>Remove interior water from the crawl space or basement</td>
</tr>
</tbody>
</table>

²⁶ ASTM Moisture Control in Buildings Manual  
²⁷ ASTM Moisture Control in Buildings Manual  
²⁸ ASTM Moisture Control in Buildings Manual  
²⁹ ASTM Moisture Control in Buildings Manual  
³⁰ ASTM Moisture Control in Buildings Manual
**Topic: Crawl Spaces**  
**Subtopic: Site Preparation**

15) **Detail Name:** Preliminary Dehumidification

**Desired Outcome:**
- A dry and moisture controlled space ensured

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Close vents</td>
<td>Vents and other openings will be closed</td>
<td>Reduce moisture load coming from outside of the crawl space</td>
</tr>
<tr>
<td>2</td>
<td>Drying</td>
<td>Crawl space area will be dried until any liquid moisture is eliminated</td>
<td>Reduce moisture in the crawl space</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Improve work environment</td>
</tr>
<tr>
<td>3</td>
<td>Drying time</td>
<td>Space will be dehumidified until wood moisture content in solid, untreated lumber is less than 20%</td>
<td>Reduce moisture content of wood</td>
</tr>
</tbody>
</table>
### Topic: Crawl Spaces

**Subtopic:** Site Preparation

#### 16) Detail Name: Negative Pressure Contamination Control

**Desired Outcome:**
- Contaminants prevented from entering house during work process

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Exterior sealing</td>
<td>Openings in the crawl space exterior foundation wall will be closed to maximize negative pressure (close the vents)</td>
<td>Minimize leakage area between crawl space and exterior</td>
</tr>
<tr>
<td>2</td>
<td>Interior sealing</td>
<td>Penetrations between the crawl space and living space will be sealed ³¹</td>
<td>Minimize air leakage from crawl space to living space</td>
</tr>
<tr>
<td>3</td>
<td>Pressure</td>
<td>A device will be installed (e.g., fan) to exhaust air out of the crawl space until the ground moisture barrier is installed in the crawl space</td>
<td>Prevent contaminants from entering house</td>
</tr>
</tbody>
</table>

³¹ ASTM C1193 – 05a section 16
³² ASTM E1827-96(2007)
## Topic: Crawl Spaces

**Subtopic:** Site Preparation

### 17) Detail Name: Sealing Floor Penetrations

**Desired Outcome:**
- Air leakage prevented

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Backing and infill</td>
<td>Backing or infill will be provided as needed to meet the specific characteristics of the selected sealant and the characteristics of the penetration. The backing or infill will not bend, sag or move once installed.</td>
<td>Ensure resulting closure is permanent and supports any load such as insulation. Ensure sealant does not fall out.</td>
</tr>
<tr>
<td>2</td>
<td>Sealant selection</td>
<td>Sealants will be used to fill holes no larger than recommended by manufacturer specifications. Sealants will be compatible with all adjoining surfaces. Sealants will be continuous and meet fire barrier specifications.</td>
<td>Create a permanent seal. Ensure sealant meets or exceeds the performance characteristics of the surrounding materials.</td>
</tr>
</tbody>
</table>

33 ASTM C1193 - 09
34 ASTM C1193 - 09
|   | High temperature application | Only non-combustible materials will be used in contact with chimneys, vents and flues \(^{35}\) | Prevent a fire hazard |

\(^{35}\) ASTM C1193 - 09
**Topic:** Crawl Spaces  
**Subtopic:** Site Preparation

18) **Detail Name:** Regional Considerations

<table>
<thead>
<tr>
<th>Row</th>
<th>Region</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very Cold</td>
<td><em>There are currently no regional considerations for this section</em></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Mixed Humid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Hot Humid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Marine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Hot Dry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Topic: Crawl Spaces**

**Subtopic:** Vented Crawl Spaces

**19) Detail Name:** Ground Moisture Barrier

**Desired Outcome:**
- Durable, effective ground moisture barrier provides ongoing access and minimizes ground vapor

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scheduling</td>
<td>The ground moisture barrier will be installed last</td>
<td>Protect ground moisture barrier from damage during other crawl space work</td>
</tr>
<tr>
<td>2</td>
<td>Coverage</td>
<td>A ground moisture barrier that covers 100% of the exposed crawl space floor will be installed</td>
<td>Reduce ground moisture entering the crawl space</td>
</tr>
<tr>
<td>3</td>
<td>Material specification</td>
<td>A ground moisture barrier with a rating of no more than .1 perm will be used</td>
<td>Ensure crawl space is accessible for service and maintenance without damaging the integrity of the ground moisture barrier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A minimum expected service life of 10 years will be ensured</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A ground moisture barrier will be used that meets tear and puncture resistance standard ASTM D703</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Overlap seams</td>
<td>When seams exist, they will be overlapped a minimum of 12” using “reverse or upslope lapping” technique</td>
<td>Keep water under the liner</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reduce the likelihood of damage at seams</td>
</tr>
</tbody>
</table>

36 ASTM Moisture Control in Buildings Manual
37 IBC 1203.3.2 and IECC 402.2.9
38 ASTM C1136 - 10
39 ASTM E1643 – 98 section 5
| 5 | Fastening | Ground moisture barrier will be fastened to ground with durable fasteners 40
|   |   | A minimum expected service life of 10 years will be ensured 41
|   |   | Prevent movement of the ground moisture barrier

---

40 ASTM E1643 – 98 section 6.4
41 ASTM C1136 - 10
**Topic: Crawl Spaces**  
**Subtopic:** Vented Crawl Spaces

**20) Detail Name:** Venting

**Desired Outcome:**  
- Pollutants effectively vented

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Venting</td>
<td>IRC 2009 (1203) or local codes will be followed 42</td>
<td>Provide ventilation for pollutant sources (e.g., moisture, radon, soil gases)</td>
</tr>
<tr>
<td>2</td>
<td>Seal Vent Penetration</td>
<td>Use materials that will keep pests out of the crawl space</td>
<td>Keep out pests</td>
</tr>
</tbody>
</table>

42 IBC 1203.3.1
# Topic: Crawl Spaces

**Subtopic:** Closed Crawl Spaces

## 21) Detail Name: Skirting Post and Pier Foundations

**Desired Outcome:**
- Protective skirting effectively installed to retard damage from natural causes such as wind, water and pests

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Skirting</td>
<td>Any materials making contact with ground will be rated for ground contact</td>
<td>Minimize pests, wind, water and freezing of pipes under house</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Skirting will be continuous around the perimeter and enclose the entire floor area below the conditioned living space</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Flashing</td>
<td>Skirting will be flashed to prevent the entrance of water</td>
<td>Prevent water from entering space under house</td>
</tr>
<tr>
<td>3</td>
<td>Fastening</td>
<td>Entire skirting will be mechanically fastened</td>
<td>Ensure lasting retrofit</td>
</tr>
</tbody>
</table>
**Topic: Crawl Spaces**  
**Subtopic: Closed Crawl Spaces**

22) **Detail Name:** Sealing the Foundation Vents

**Desired Outcome:**
- Air and moisture penetration through the existing vent into the crawl space blocked

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vent closure</td>
<td>Vent opening will be permanently closed and sealed 43</td>
<td>Prevent air and moisture penetration</td>
</tr>
</tbody>
</table>

43 IBC 1203.3.2
**Topic: Crawl Spaces**  
**Subtopic: Closed Crawl Spaces**

**23) Detail Name:** Sealing the Exterior Wall

**Desired Outcome:**
- Well sealed exterior wall prevents leakage and pests

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Seal penetrations</td>
<td>Penetrations will be sealed with a durable material 44</td>
<td>Prevent air and moisture leakage into crawl space</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A minimum expected service life of 10 years will be ensured 45</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Pest exclusion</td>
<td>If penetration is greater than ¼”, a pest-proof material will be used</td>
<td>Prevent pest entry</td>
</tr>
</tbody>
</table>

44 ASTM C1193 - 09  
45 ASTM C1136 - 10
**Topic: Crawl Spaces**  
**Subtopic: Closed Crawl Spaces**

24) **Detail Name:** Sealing Brick Curtain Wall with Piers

**Desired Outcome:**
- Well sealed exterior wall prevents leakage and pests

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Seal penetrations</td>
<td>Penetrations will be sealed with a durable material, including the following: 46</td>
<td>Reduce moisture vapor and water from entering the crawl space through the rain screen</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sealing rain screen to crawl space connection</td>
<td>Decrease probability of rot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Re-venting exterior weep holes with wicking rope</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A minimum expected service life of 10 years will be ensured 47</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Pest exclusion</td>
<td>If penetration is greater than ¼”, a pest-proof material will be used</td>
<td>Prevent pest entry</td>
</tr>
</tbody>
</table>

46 ASTM C1193 - 09  
47 ASTM C1136 - 10
Topic: Crawl Spaces
Subtopic: Closed Crawl Spaces

25) Detail Name: Vapor Retarders on Walls

**Desired Outcome:**
- Durable, effective vapor retarder minimizes leakage from ground and air

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Air barrier and vapor retarder</td>
<td>An air barrier and vapor retarder will be installed on the interior side of the exterior wall of the closed crawl space with a rating of no more than .13 perm.</td>
<td>Prevent air and moisture penetration</td>
</tr>
<tr>
<td>2</td>
<td>Coverage</td>
<td>A material will be installed a minimum of 1’ or as high as possible above outside grade.</td>
<td>Prevent air and moisture penetration</td>
</tr>
<tr>
<td>3</td>
<td>Termite inspection gap</td>
<td>Where termite pressure exists, a 3” inspection gap will be maintained from the top of the insulation to the bottom of any wood.</td>
<td>Allow for termite detection</td>
</tr>
<tr>
<td>4</td>
<td>Attachment</td>
<td>The vapor retarder will be attached with a durable connection. The vapor retarder will be sealed at punctures and seams to prevent air entry. A minimum expected service life of 10 years will be ensured.</td>
<td>Ensure vapor retarder maintains a fixed position on the exterior wall. Ensure vapor retarder is air tight</td>
</tr>
</tbody>
</table>

48 ASTM C1136 - 10
49 ASTM Moisture Control in Buildings Manual
50 ASTM E1643 – 98 section 5
51 ASTM E1643 – 98 section 5
52 ASTM C1136 - 10
| 5 | Piers and interior walls | The vapor retarder will be installed a minimum of 6” above interior grade  
The vapor retarder will be attached with a durable connection  
The vapor retarder will be sealed at punctures and seams to prevent air entry  
A minimum expected service life of 10 years will be ensured |
|---|-------------------------|------------------------------------------------------------------------------------------------|

Prevent ground moisture penetration

---

53 ASTM E1643 – 98 section 5  
54 ASTM E1643 – 98 section 5  
55 ASTM C1136 - 10
**Topic: Crawl Spaces**  
**Subtopic:** Closed Crawl Spaces

---

**26) Detail Name:** Attached Crawl Spaces Under Unconditioned Spaces

**Desired Outcome:**
- Closed, attached crawl spaces sealed but remain accessible

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Separate crawl spaces</td>
<td>A continuous air and vapor barrier between the attached crawl space under unconditioned spaces and the closed crawl space will be maintained 56</td>
<td>Prevent air and moisture penetration</td>
</tr>
<tr>
<td>2</td>
<td>Entry point</td>
<td>An entry point to the isolated attached crawl spaces under unconditioned spaces will be provided 57</td>
<td>Provide access to attached crawl space for inspections</td>
</tr>
</tbody>
</table>

56 | IECC 402.2.3  
57 | IECC 402.2.3
**Topic: Crawl Spaces**  
**Subtopic: Closed Crawl Spaces**

27) **Detail Name:** Wall Insulation  

**Desired Outcome:**  
- Closed crawl spaces insulated to achieve best thermal performance possible

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Insulation selection</td>
<td>A non-absorbent, fire-rated insulation will be used with a minimum life expectancy of 10 years</td>
<td>Improve thermal performance</td>
</tr>
<tr>
<td>2</td>
<td>Location</td>
<td>Insulation will be installed on either the exterior of interior of the exterior closed crawl space wall</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>R-value</td>
<td>Regional IECC will be followed for required R-values</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Termite inspection gap</td>
<td>Where termite pressure exists, a 3” inspection gap will be maintained from the top of the insulation to the bottom of any wood</td>
<td>Allow for termite detection</td>
</tr>
<tr>
<td>5</td>
<td>Attachment</td>
<td>Insulation will be attached with a durable connection</td>
<td>Maintain insulation performance without compromising the air or vapor barrier</td>
</tr>
<tr>
<td>6</td>
<td>Band joist and wood foundation walls</td>
<td>A vapor-diffuse insulation will be installed</td>
<td>Improve thermal performance</td>
</tr>
</tbody>
</table>

58 C1320 – 05(2009)e1  
59 E241 - 09  
60 IECC Section 301  
61 ASTM C1136 - 10
| 7 | Band joist and wood foundation walls (cold climates) | Insulation will be installed with a vapor barrier on the warm side of the insulation. Where termite pressure exists, removable band joist insulation will be installed. | Improve thermal performance. Prevent moisture condensation on the inside of the band joist or wood walls. Allow for termite inspection and drying of wood materials. |

---

62 C1320 – 05(2009)e1
Topic: Crawl Spaces  
Subtopic: Closed Crawl Spaces

28) Detail Name: Ground Moisture Barriers

**Desired Outcome:**
- Durable, effective air barrier and ground moisture barrier provide ongoing access and minimize ground vapor

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scheduling</td>
<td>The air barrier and ground moisture barrier will be installed last</td>
<td>Protect air barrier and ground moisture barrier from damage during other work in the crawl space</td>
</tr>
</tbody>
</table>
| 2   | Coverage                  | An air barrier and ground moisture barrier, covering 100% of the exposed crawl space floor will be installed and sealed to the wall's air and moisture barrier | Reduce ground vapor entering the crawl space  
Create a continuous and durable connection between the wall and ground air and moisture barriers |
| 3   | Material specification    | A ground moisture barrier with a rating of no more than .1 perm will be used  
A minimum expected service life of 10 years will be ensured  
A ground moisture barrier will be used that meets tear and puncture resistance standard ASTM D703 | Reduce ground vapor from entering the crawl space  
Ensure crawl space is accessible for service and maintenance without destroying the integrity of the moisture barrier |
| 4   | Overlap seams             | When seams exist, they will be overlapped a minimum of 12” with “reverse or upslope lapping” technique | Keep water under the liner |

63 ASTM Moisture Control in Buildings Manual  
64 IBC 1203.3.2 and IECC 402.2.9  
65 ASTM C1136 - 10  
66 ASTM E1643 – 98 section 5
<table>
<thead>
<tr>
<th></th>
<th></th>
<th>For wall to floor connection, the wall moisture barrier will be installed under the ground moisture barrier 67</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Fastening</td>
<td>The air barrier and ground moisture barrier will be fastened to ground to prevent movement 68  &lt;br&gt; A minimum expected service life of 10 years will be ensured 69  &lt;br&gt; Prevent movement and uplift of the air barrier and ground moisture barrier</td>
</tr>
<tr>
<td>6</td>
<td>Sealing seams</td>
<td>A durable sealant compatible with the air barrier and ground moisture barrier will be used 70  &lt;br&gt; A minimum expected service life of 10 years will be ensured 71  &lt;br&gt; Maintain continuous air barrier and ground moisture barrier</td>
</tr>
<tr>
<td>7</td>
<td>Air barrier, ground moisture barrier penetrations, including fastener penetrations</td>
<td>A durable sealant compatible with the air barrier and ground moisture barrier will be used  &lt;br&gt; Physical attachments will be provided where practical (e.g., masonry columns, footings)  &lt;br&gt; A minimum expected service life of 10 years will be ensured 72  &lt;br&gt; Maintain continuous air barrier and ground moisture barrier</td>
</tr>
<tr>
<td>8</td>
<td>Drainage</td>
<td>The air barrier and ground moisture barrier will not interfere with the established drainage pattern  &lt;br&gt; Ensure proper drainage</td>
</tr>
</tbody>
</table>

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67 E241 - 09  
68 ASTM E1643 – 98 section 6.4  
69 ASTM C1136 - 10  
70 ASTM C1193 - 09  
71 ASTM C1136 - 10  
72 ASTM C1136 - 10
<table>
<thead>
<tr>
<th></th>
<th>Drainage points</th>
<th>Interior drainage collection points will be accessible from above and below the air barrier and ground moisture barrier</th>
<th>Remove water above and below the air barrier and ground moisture barrier</th>
</tr>
</thead>
</table>

9

|   | Drainage points | Interior drainage collection points will be accessible from above and below the air barrier and ground moisture barrier | Remove water above and below the air barrier and ground moisture barrier |

---

**Interior drainage collection points**

Remove water above and below the air barrier and ground moisture barrier
# Topic: Crawl Spaces

**Subtopic:** Closed Crawl Spaces

### 29) Detail Name: Crawl Space Conditioning

**Desired Outcome:**
- Humidity in closed crawl space is controlled to reduce moisture damage, energy consumption and pests

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No return pathway to living space</td>
<td>A return pathway from the crawl space to the living space will not be allowed</td>
<td>Improve indoor air quality (IAQ) in the living space</td>
</tr>
<tr>
<td>2</td>
<td>Option 1: Dehumidifier</td>
<td>Option 1 may be used in combination with any other specified options</td>
<td>Maintain low relative humidity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A permanent, low-temperature, auto-restart, minimum ENERGY STAR® rated dehumidifier will be installed with a minimum rated capacity of 15 pints per day</td>
<td>Reduce conditions conducive to pest activity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Condensate will be drained to daylight or a condensation pump</td>
<td>Reduce conditions conducive to mold growth and wood rot</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Improve IAQ in the conditioned space</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Improve equipment service life</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Save energy in cooling-dominated climates</td>
</tr>
<tr>
<td>3</td>
<td>Option 2: Supply air</td>
<td>Option 2 may be used in combination with any other specified options</td>
<td>Maintain low relative humidity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air from a central forced-air conditioning system will be supplied at a rate of 1 cubic foot per minute (CFM) per 30 square feet of closed crawl space area</td>
<td>Reduce conditions conducive to pest activity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reduce conditions conducive to mold</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
</tbody>
</table>
| **Option 3: Conditioned house air** | The supply air duct will be fitted with a backflow damper | growth and wood rot  
Improve IAQ in the conditioned space  
Improve equipment service life  
Save energy in cooling-dominated climates  
Prevent crawl space air from entering the living space when forced-air system is off |
| 4 | Option 3 may be used in combination with any other specified options | Maintain low relative humidity  
Reduce conditions conducive to pest activity  
Reduce conditions conducive to mold growth and wood rot  
Improve IAQ in the conditioned space  
Improve equipment service life  
Save energy in cooling-dominated climates |
| 5 | A continuous-duty, HVI-rated, 1-sone or less fan will be installed that supplies 1 CFM of conditioned house air per 50 square feet of closed crawl space area  
Optional: An air relief vent to the outside may be installed | A continuous-duty, HVI-rated, 1-sone or less fan will be installed that exhausts 1 CFM of closed crawl space air per 50 square feet of closed crawl space area | Maintain low relative humidity  
Reduce conditions conducive to pest activity  
Reduce conditions conducive to mold |
<table>
<thead>
<tr>
<th></th>
<th>Monitoring alarm system</th>
<th>A durable humidity monitoring system with alarm capability will be installed</th>
<th>Alert occupant to system failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td></td>
<td>A minimum expected service life of 10 years will be ensured</td>
<td></td>
</tr>
</tbody>
</table>

 growth and wood rot
Improve IAQ in the conditioned space
Improve equipment service life
Save energy in cooling-dominated climates

---

73 ASTM C1136 - 10
### Topic: Crawl Space

#### Subtopic: Closed Crawl Spaces

**30) Detail Name:** Regional Considerations

<table>
<thead>
<tr>
<th>Row</th>
<th>Region</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very Cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Mixed Humid</td>
<td>There will be a 3” view gap in closed crawl spaces for areas of high or moderate termite infestation. Gap will be covered by a removable insulation plug and there will be removable band joist insulation to facilitate termite inspections. A leak alarm will be installed in the crawl space and basement.</td>
<td>Ensure ease of detection of termite infestation and reduce energy loss. Provide water detection in case of malfunction.</td>
</tr>
<tr>
<td>4</td>
<td>Hot Humid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Marine</td>
<td>Air and wind will be blocked from entering crawl space. Ground moisture barrier will be installed up to grade, but not above.</td>
<td>Reduce moisture laden air from entering the crawl space. Ensure crawl space wall can dry to the exterior or interior as needed.</td>
</tr>
<tr>
<td>6</td>
<td>Hot Dry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Basements

Insulation and Conditioning:
  31) Basement Wall Insulation – No Ground Water Leakage
  32) Basement Wall Insulation – Ground Water Leakage
  33) Dehumidification
**Topic: Basements**

**Subtopic: Insulation and Conditioning**

31) **Detail Name:** Basement Wall Insulation – No Ground Water Leakage

**Desired Outcome:**
- Basement insulation improves thermal performance and ensures sufficient drying potential

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R-value</td>
<td>Regional IECC will be followed for required R-values</td>
<td>Improve thermal performance of the basement and living space</td>
</tr>
<tr>
<td></td>
<td></td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Air barrier</td>
<td>A continuous air barrier will be installed on the warm side of the insulation</td>
<td>Prevent condensation on the basement wall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Vapor permeability</td>
<td>When absorbent insulation materials are installed, assembly will remain vapor</td>
<td>Provide drying potential to the basement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>permeable to the interior</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>76</td>
<td></td>
</tr>
</tbody>
</table>

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74 IECC section 301  
75 ASTM C1320 - 05(2009)e1  
76 ASTM C1320 - 05(2009)e1
## Topic: Basements
### Subtopic: Insulation and Conditioning

**32) Detail Name:** Basement Wall Insulation – Ground Water Leakage

**Desired Outcome:**
- Basement insulation improves thermal performance and ensures sufficient drying potential

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Drainage</td>
<td>A continuous drainage plane at the interior surface of the exterior basement wall will be created from the top of the wall to a drainage field at the bottom of the wall or sub-slab. Drainage field will be run to daylight or pump to the outside</td>
<td>Remove moisture on the surface of the exterior basement wall</td>
</tr>
<tr>
<td>2</td>
<td>Rough finish walls (e.g., rubble walls)</td>
<td>Drainage plane will be replaced with a waterproof membrane. Only a non-absorbent insulation will be applied that adheres to the waterproof membrane without voids. Drainage field will be run to daylight or pump to the outside</td>
<td>Create an air and moisture barrier on the interior side of the exterior basement wall and allow the insulation to conform to the irregularity of the surface. Improve thermal performance of the basement and the living space</td>
</tr>
<tr>
<td>3</td>
<td>Thermal barrier, insulation</td>
<td>A non-absorbent insulation will be used with a minimum expected service life of 10 years. A fire-rated material will be used if the insulation is left exposed.</td>
<td>Improve thermal performance of the basement and the living space</td>
</tr>
</tbody>
</table>

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77 ASTM C1136 - 10
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4</strong></td>
<td><strong>Location</strong></td>
<td>Insulation will be installed continuously from the top of the band joist to the top of the slab</td>
</tr>
<tr>
<td><strong>5</strong></td>
<td><strong>Termite protection</strong></td>
<td>Where termite pressure exists, if sub-slab drainage is installed, termite treatment will be performed before re-installing the slab</td>
</tr>
<tr>
<td><strong>6</strong></td>
<td><strong>Insulation attachment</strong></td>
<td>Insulation will be attached with a durable connection ⁷⁸ A minimum expected service life of 10 years will be ensured ⁷⁹</td>
</tr>
<tr>
<td><strong>7</strong></td>
<td><strong>R-value</strong></td>
<td>Regional IECC will be followed for required R-value ⁸⁰</td>
</tr>
<tr>
<td><strong>8</strong></td>
<td><strong>Sealing</strong></td>
<td>A continuous air barrier on the warm side of the thermal boundary will be installed, including floor-to-wall and wall-to-ceiling connections</td>
</tr>
<tr>
<td><strong>9</strong></td>
<td><strong>Finish wall requirements</strong></td>
<td>IRC will be followed for finish wall details in basements</td>
</tr>
</tbody>
</table>

⁷⁸ ASTM C1320 - 05(2009)e1  
⁷⁹ ASTM C1136 - 10  
⁸⁰ IECC section 301
**Topic: Basements**  
**Subtopic: Insulation and Conditioning**

33) **Detail Name:** Dehumidification

**Desired Outcome:**  
- Basement humidity controlled with supplemental dehumidification

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dehumidifier</td>
<td>A permanent, low-temperature, auto-restart, minimum ENERGY STAR® rated dehumidifier will be installed</td>
<td>Maintain a dry basement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manufacturer specifications will be followed for size and use</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Condensate will be drained to daylight or a condensation pump</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Dehumidification for divided spaces</td>
<td>Drying will be provided to all basement areas</td>
<td>Reduce conditions conducive to mold growth, wood rot and pests</td>
</tr>
<tr>
<td>3</td>
<td>Relative humidity</td>
<td>All basement spaces will be maintained at a relative humidity of less than 45%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Condensing surfaces (e.g., cold water pipes)</td>
<td>Condensing surfaces in basement will be insulated and sealed</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Dehumidification (option for dry climates and heating-dominated climates seasonally)</td>
<td>Ventilation in the basement will be controlled to maintain relative humidity of less than 45%</td>
<td></td>
</tr>
</tbody>
</table>
SECTION 8: BASELOAD

Table of Contents

Health and Safety

Safe Work Practices: ¹
1) Baseload Worker Safety

Baseload

Plug Load:
2) Refrigerator and Freezer Replacement
3) Cleaning and Tuning Existing Refrigerators and Freezers
4) Entertainment and Computer Systems and Components Replacement
5) Lighting
6) Washing Machine
7) Clothes Dryer Replacement
8) Dehumidifiers
9) Removal of Electrically Heated Waterbed Mattress
10) Regional Considerations

Water Heating

Energy Use:
11) Water Heater Selection
12) Shower Head and Faucet Aerator

Installation and Replacement:
13) Storage Type Appliance
14) On Demand Appliance
15) Regional Considerations

Routine Maintenance:
16) Storage Type Appliance
17) On Demand Appliance

¹ Appendix D – OSHA Personal Protective Equipment Standards
Shading:

Landscaping:
   18) Indigenous Shading
Health and Safety

Safe Worker Practices:

1) Baseload Worker Safety
## Topic: Health and Safety
### Subtopic: Safe Work Practices

1) **Detail Name:** Baseload Worker Safety

**Desired Outcome:**
- Work is completed safely without injury or hazardous exposure

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Hand protection</strong></td>
<td>Durable and wrist protecting gloves will be worn that can withstand work activity (^2)</td>
<td>Minimize skin contact with contaminants</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Protect hands from sharp objects</td>
</tr>
<tr>
<td>2</td>
<td><strong>Respiratory protection</strong></td>
<td>Respirators appropriate for the contaminants present will be worn (e.g. N-95 or equivalent face mask) (^3)</td>
<td>Minimize exposure to airborne contaminants (e.g. insulation materials, mold spores, feces, bacteria, chemicals)</td>
</tr>
<tr>
<td>3</td>
<td><strong>Electrical safety</strong> (^4,5)</td>
<td>An electrical safety assessment will be performed</td>
<td>Avoid electrical shock and arc flash hazards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All electric tools will be protected by Ground-Fault Circuit Interrupters (^6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Extension cords used with portable electric tools will be of three-wire type</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Worn or frayed electric cords will not be used</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metal ladders will be avoided</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Special precautions to avoid electrical shock will be taken if knob and tube wiring is present</td>
<td></td>
</tr>
</tbody>
</table>

\(^2\) OSHA Technical Manual Section VIII: Chapter 1, part III

\(^3\) OSHA Technical Manual Section VIII: Chapter 2, section IV


\(^5\) 29 CFR 1926 Subpart K – Electrical

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>For arc flash hazards, NFPA 70E will be consulted</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td><strong>Protective clothing</strong>&lt;sup&gt;7&lt;/sup&gt;</td>
<td>If contaminants are present, (e.g. mercury from broken light bulb) gloves will be worn&lt;br&gt;Eye protection will always be worn (e.g. safety glasses, goggles if not using full face respirator)</td>
</tr>
<tr>
<td>5</td>
<td><strong>Confined space safety</strong>&lt;sup&gt;8,9&lt;/sup&gt;</td>
<td>Access and egress points will be located before beginning work&lt;br&gt;Inspection will be conducted for frayed electrical wires&lt;br&gt;Adequate ventilation will be provided&lt;br&gt;Use of toxic material will be reduced</td>
</tr>
<tr>
<td>6</td>
<td><strong>Power tool safety</strong>&lt;sup&gt;10&lt;/sup&gt;</td>
<td>Power tools will be inspected and used according to manufacturer specifications to eliminate hazards associated with missing ground prongs, ungrounded circuits, misuse of power tools, noise and improper or defective cords or extension cords&lt;br&gt;All devices used will be verified as GFI protected or double insulated</td>
</tr>
<tr>
<td>7</td>
<td><strong>Chemical safety</strong></td>
<td>The least toxic suitable material will be chosen&lt;br&gt;Chemicals will be handled</td>
</tr>
</tbody>
</table>

---

7 OSHA Technical Manual Section VIII: Chapter 1, part III
8 ASTM D4276 - 02(2007)
10 29 CFR 1910 Subpart P - Hand and portable powered tools and other hand-held equipment
| 8 | Ergonomic safety | Proper equipment will be used for work |
| 9 | Hand tool safety | Hand tools will be used for intended purpose |
| 10 | Slips, trips and falls | Caution will be used around power cords, hoses, tarps and plastic sheeting |
| 11 | Heat or thermal stress | Appropriate ventilation, hydration, rest breaks, and cooling equipment will be used |

According to manufacturer instructions or Material Safety Data Sheet (MSDS) standards to eliminate hazards associated with volatile organic compounds (VOCs), sealants, insulation, dust, foams, asbestos, lead, mercury fibers and oil tank mercury.  

Proper lifting techniques will be used.  

Avoid injuries from awkward postures, repetitive motions and improper lifting.  

Proper lifting techniques will be used.  

Reduce injuries.  

Precautions will be taken when ladders are used, when working at heights, or when balancing on joists.  

Walk boards will be used when practical.  

Appropriate footwear and clothing will be worn.  

Eliminate injuries due to slips, trips and falls.  

Appropriate ventilation, hydration, rest breaks, and cooling equipment will be used.  

Dial 911 when necessary.  

Reduce heat stroke, heat stress and cold stress related injuries.  

11 29 CFR 1910 Subpart Z - Toxic and Hazardous Substances  
13 29 CFR 1910 Subpart P - Hand and portable powered tools and other hand-held equipment  
14 29 CFR 1926 Subpart M - Fall Protection  
15 29 CFR 1926 Subpart C - General Safety and Health Provisions
|   | Prevention through design | Design will be incorporated to eliminate or minimize hazards (e.g. material selection, access to equipment for installation and maintenance, placement of equipment, duct work and condensate lines) ¹⁶ | Prevent worker injuries and exposure to toxic substances and physical hazards |

¹⁶ 29 CFR 1926 Subpart C - General Safety and Health Provisions
**Baseload**

**Plug Load:**

2) Refrigerator and Freezer Replacement  
3) Clean and Tune Existing Refrigerators and Freezers  
4) Entertainment and Computer Systems and Components Replacement  
5) Lighting  
6) Washing Machine  
7) Clothes Dryer Replacement  
8) Dehumidifiers  
9) Removal of Electrically Heated Waterbed Mattress  
10) Regional Considerations
**Topic: Baseload**

**Subtopic: Plug Load**

2) **Detail Name:** Refrigerator and Freezer Replacement

** Desired Outcome:**
- A more energy efficient appliance installed

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Selection| Appliance will have an efficiency level of 40% or better compared to minimum federal requirements \[17\]  
Appliance will fit in the available space without blocking access to light switches, cabinets, etc  
Appliance will carry an adequate warranty, which will provide a replacement appliance if repeated issues relating to health, safety or performance occur | Ensure occupant satisfaction with appliance                                    |
| 2   | Installation| Appliance will be installed according manufacturer specifications and local codes \[18\]  
Any penetrations to the exterior of the home created by the installation of the appliance will be sealed  
Energy related appliance controls will be demonstrated to the occupant  
Specific information on the | Achieve intended appliance function  
Preserve food at low energy use  
Educate occupant on how to operate and maintain the appliance                   |

\[17\] National Appliance Energy Conservation Act (NAECA)  
\[18\] NFPA 70A
| 3 | Decommissioning | Appliances replaced by new units will be recycled or disposed of properly

Appliances infested with pests will be enclosed before moving | Prevent reuse of inefficient equipment and components

Protect the environment

Protect worker safety |
**Topic: Baseload**
**Subtopic: Plug Load**

3) **Detail Name:** Cleaning and Tuning Existing Refrigerators and Freezers

**Desired Outcome:**
- Energy used for food preservation reduced

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Clean and tune</strong></td>
<td>Dirty or clogged coils will be cleaned</td>
<td>Reduce energy use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air flow to the coils will be provided as required by manufacturer</td>
<td>Improve performance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Appliance will be located away from heat sources (e.g., supply registers, direct sunlight) if possible</td>
<td>Educate occupant on how to operate and maintain the appliance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interior temperatures will be measured, and the appliance must maintain:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Freezer temperature at 0°</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fresh food at 35-40°</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specific information about the proper maintenance of the equipment will be provided to the occupant</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Condensation control switch will be left in the appropriate position, given occupant preference and moisture load in the house</td>
<td></td>
</tr>
</tbody>
</table>
## Topic: Baseload
### Subtopic: Plug Load

4) **Detail Name:** Entertainment and Computer Systems and Components Replacement

**Desired Outcome:**
- Energy used for electronic entertainment and computer use reduced while effective performance is maintained

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Selection</td>
<td>Category of equipment selected will meet occupant preferences and have the lowest available energy use (e.g., Plasma vs. light-emitting diode (LED))</td>
<td>Reduce energy use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment will have a minimum energy-efficiency level of ENERGY STAR® 19</td>
<td>Satisfy occupant with appliance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment will be selected that does not have to be left on during non-use periods for updates. (e.g., gaming systems, set-top boxes)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standby losses for system will be 1 watt or less</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Installation</td>
<td>Equipment will be installed according to manufacturer specifications (e.g., air circulation) and meet all applicable codes</td>
<td>Reduce energy use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Any penetrations to the exterior of the home created by the installation of the equipment will be sealed</td>
<td>Ensure equipment is available for use when needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All energy-saving features will</td>
<td>Ensure equipment is convenient to turn off when not in use</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Occupant will be educated on how to operate and maintain</td>
</tr>
</tbody>
</table>

19 National Appliance Energy Conservation Act (NAECA)
|   |   | be enabled unless specifically directed otherwise by the occupant |
|   |   | A readily-accessible means of disconnection (e.g., power strip, timer) will be provided for equipment that must be disconnected from the power source to avoid stand-by losses and whose performance will not be damaged by being disconnected |
|   |   | All equipment controls will be demonstrated to the occupant |
|   |   | Specific information about the proper maintenance of the equipment will be provided to the occupant |
|   |   | Warranty information, operation manuals and installer contact information will be provided to the occupant |

3 | Decommissioning | Equipment will be recycled or disposed of using EPA Responsible Recycling (R2) initiative principles | Prevent reuse of inefficient equipment and components |
|   |   | Reduce waste and properly dispose of hazardous materials |
# Topic: Baseload

**Subtopic:** Plug load

5) **Detail Name:** Lighting

**Desired Outcome:**
- Energy used for lighting reduced while maintaining adequate and safe lighting levels

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Day lighting</td>
<td>Window coverings (e.g., blinds, shades, moveable insulation) will be replaced or maneuvered to maximize useful daylight. Active and passive day lighting will be installed where appropriate (e.g., install solar-light tube, light shelf, skylights)</td>
<td>Reduce energy use without negative consequences (e.g., glare, unintentional heating)</td>
</tr>
<tr>
<td>2</td>
<td>Selection</td>
<td>All bulbs, fixtures and controls will be appropriate for the intended application (e.g., enclosed, orientation, dimmable, potential for breakage, indoor and outdoor)</td>
<td>Provide improved lighting quality at lower energy use. Select equipment that will not be an unnecessary barrier to future technologies. Avoid inferior products and unsatisfied occupants</td>
</tr>
</tbody>
</table>

20 40 CFR 271.13
<table>
<thead>
<tr>
<th>3</th>
<th>Installation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>lamp (CFL), light-emitting diode (LED)</strong></td>
<td></td>
</tr>
<tr>
<td>All bulbs, fixtures and controls will be ENERGY STAR® rated where applicable</td>
<td></td>
</tr>
<tr>
<td>When possible, bulbs, fixtures and controls will be selected that will facilitate the use of future lighting technologies (e.g., LEDs)</td>
<td></td>
</tr>
<tr>
<td>When incandescent bulbs cannot be replaced, or where occupant chooses not to replace, a dimmer will be selected</td>
<td></td>
</tr>
<tr>
<td>Power quality will be evaluated before new lighting is selected</td>
<td></td>
</tr>
<tr>
<td>Bulb replacements will be chosen based on expected durability, light quality and lifetime energy use of the bulb</td>
<td></td>
</tr>
<tr>
<td>Controls to turn off lights when not needed (e.g., no one in room) will be provided</td>
<td></td>
</tr>
<tr>
<td>All bulbs, fixtures and controls will be UL-approved 21</td>
<td></td>
</tr>
<tr>
<td>Reduce energy use 24</td>
<td></td>
</tr>
<tr>
<td>Ensure mishandling does not compromise durability of bulb</td>
<td></td>
</tr>
<tr>
<td>Educate occupants on safe</td>
<td></td>
</tr>
</tbody>
</table>

21 40 CFR 271.13  
24 NFPA 70A
<table>
<thead>
<tr>
<th>Exterior of the home created by the installation of the lighting will be sealed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulbs will be installed by holding base, not bulb</td>
</tr>
<tr>
<td>Information on proper disposal of CFL bulbs will be provided to the occupant</td>
</tr>
<tr>
<td>EPA standard for disposal will be cited in the information provided</td>
</tr>
<tr>
<td>Information on how to obtain replacement bulbs will be provided to the occupant</td>
</tr>
<tr>
<td>Bulbs or fixtures not needed by occupant will be removed</td>
</tr>
<tr>
<td>Lighting controls will be demonstrated to the occupant</td>
</tr>
<tr>
<td>Specific information about proper maintenance of the equipment will be provided to the occupant</td>
</tr>
<tr>
<td>Warranty information, operation manuals and installer contact information will be provided to the occupant</td>
</tr>
</tbody>
</table>

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22 40 CFR 271.13
23 NFPA 70A
<table>
<thead>
<tr>
<th></th>
<th>Recessed lights</th>
<th>Liability and inefficiency of recessed lights will be addressed through one of the following: 25</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Recessed lights</td>
<td>• Removal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Replacement (e.g., other fixture, airtight insulation contact (IC)-rated recessed)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Insertion of airtight LED</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Insertion of other fixtures that address safety, heat buildup, lighting efficiency, air tightness and effectiveness of surrounding insulation</td>
</tr>
<tr>
<td>5</td>
<td>Decommissioning</td>
<td>All bulbs, fixtures and controls to be discarded will be properly disposed of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improve lighting efficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Address safety, heat buildup, lighting efficiency, air tightness and effectiveness of surrounding insulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prevent reuse of inefficient equipment and components</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Protect the environment</td>
</tr>
</tbody>
</table>

25 NFPA 70A
## Topic: Baseload
### Subtopic: Plug Load

6) **Detail Name:** Washing Machine

**Desired Outcome:**
- Energy and environmental impact for washing clothes reduced

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Selection | Minimum appliance efficiency will be ENERGY STAR® and WaterSense® or better 26

Classes within ENERGY STAR standards will be considered so as to achieve greater savings 27

Adequate clearance will be maintained around appliance when fit in space available so access to cabinets and light switches are not blocked

Appliance will be covered by an adequate warranty

Equipment will be selected with features that reduce both peak electric demand and absolute energy use and water use

Standby losses for equipment will be 1 watt or less | Reduct energy use

| 2   | Installation | Appliance will be installed according to manufacturer specifications (e.g., leveling, plumbing connection, electrical connection, interior) | Ensure equipment functions as designed

Reduce water consumption |

---

26 National Appliance Energy Conservation Act (NAECA)
27 National Appliance Energy Conservation Act (NAECA)
<table>
<thead>
<tr>
<th>lighting) and meet all applicable codes 28</th>
<th>Prevent water damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shut-off valves will be installed, if not already present</td>
<td>Educate occupants on how to maintain their washer to ensure savings</td>
</tr>
<tr>
<td>Hoses that can withstand water pressure at the location will be installed</td>
<td></td>
</tr>
<tr>
<td>If located in conditioned or finished area, overflow pan will be installed and drained to a safe location</td>
<td></td>
</tr>
<tr>
<td>Any penetrations to the exterior of the home created by the installation of the appliance will be sealed 29</td>
<td></td>
</tr>
<tr>
<td>Energy-related appliance controls will be demonstrated to the occupant</td>
<td></td>
</tr>
<tr>
<td>Specific information about proper maintenance of the equipment will be provided to the occupant</td>
<td></td>
</tr>
<tr>
<td>Water quality will be evaluated via pH and hardness tests, and the occupant will be informed on detergent levels and type to optimize performance</td>
<td></td>
</tr>
<tr>
<td>Warranty information, operation manuals and installer contact information will be provided to the</td>
<td></td>
</tr>
</tbody>
</table>

28 NFPA 70A  
29 ASTM C1193 - 09
<table>
<thead>
<tr>
<th></th>
<th>occupant</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Decommissioning</td>
<td>Replaced appliances will be recycled or disposed of properly, including older equipment switches containing mercury</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduce waste</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Protect occupant health</td>
</tr>
</tbody>
</table>
**Topic: Baseload**  
**Subtopic: Plug Load**

7) **Detail Name:** Clothes Dryer Replacement

**Desired Outcome:**
- Energy and environmental impact for drying clothes reduced

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Selection</td>
<td>Appliance will have a minimum efficiency level of ENERGY STAR® or better&lt;br&gt;Total energy use will be factored into the selection process if fuel switching is being considered ³⁰&lt;br&gt;Drayer will be equipped with moisture sensor&lt;br&gt;Equipment will be selected with energy features that reduce both peak electric demand and absolute energy use&lt;br&gt;Standby losses for equipment will be 1 watt or less&lt;br&gt;A dryer best matched to the venting options will be selected (e.g., central location, length of vent, cost of venting)</td>
<td>Reduce energy use&lt;br&gt;Avoid increasing total energy use (gas and electric) when fuel switching</td>
</tr>
<tr>
<td>2</td>
<td>Installation</td>
<td>Appliance will be installed according to manufacturer specifications (e.g., leveling, plumbing connection, electrical connection, ³¹)</td>
<td></td>
</tr>
</tbody>
</table>

³⁰ National Appliance Energy Conservation Act (NAECA)  
³¹ NFPA 70A
interior lighting) and meet all applicable codes.\(^{32}\)

If existing venting does not meet the following criteria (as well as manufacturer specifications and applicable codes), new venting will be installed using the following specifications.\(^{33}\)

- Appliance will be vented to the outside using metal-to-metal venting
- Venting design will meet standards for optimal venting
- Venting will not be constricted or blocked
- Only tape or clamps will be used on vents—no screws
- Pest screen will be installed at the termination
- At least 3' of the vent closest to the exterior of the house will be insulated

Ensure equipment functions as designed
- Install appliance safely and effectively
- Reduce energy use
- In case of fuel switching, reduce cost

If a combustion appliance is used, the house must pass a Combustion Appliance Zone test upon completion of installation.\(^{34}\)

\(^{32}\) NFPA 70A  
\(^{33}\) Standard 62.2-2010  
\(^{34}\) ASTM E1998 - 02(2007)
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Any penetrations to the exterior of the home created by the installation of the appliance will be sealed 35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy-related appliance controls will be demonstrated to the occupant 36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Specific information of the proper maintenance of the equipment will be provided to the occupant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Warranty information, operation manuals and installer contact information will be provided to the occupant</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>Decommissioning</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Replaced appliances will be recycled or disposed of properly, including older equipment switches containing mercury 37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevent the reuse of inefficient equipment and its components</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduce waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Protect occupant health</td>
<td></td>
</tr>
</tbody>
</table>

35 ASTM C1193 - 09  
36 Standard 62.2-2010  
37 40 CFR 271.13
**Topic: Baseload**

**Subtopic: Plug Load**

8) **Detail Name:** Dehumidifiers

**Desired Outcome:**
- Energy used to control humidity in conditioned spaces reduced

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Selection | Equipment will have a minimum efficiency level of ENERGY STAR® or better 38  
Equipment will have a fan-off option  
Equipment will retain settings after power-off  
Equipment will have features that reduce both peak electric use (e.g., internal and external timers) and absolute energy use  
Equipment will have standby losses of 1 watt or less  
Controls will be labeled so they are understandable, readable and accurate for occupant needs  
Operating environment will be determined and appropriate equipment will be selected for that environment (e.g., low temperature and high relative humidity) | Reduce energy use  
Provide durable equipment  
Control moisture  
Provide equipment appropriate for occupant use |

38 National Appliance Energy Conservation Act (NAECA)
### Installation

Installation will proceed only when the following applicable steps have been taken to control moisture:

- Windows, doors and vents in crawl space are closed
- Downspouts are redirected away from foundation
- Moisture from drying clothes is vented to the outside
- Sump pit is covered
- Dirt in crawl space is covered with a vapor barrier
- Plumbing leaks are eliminated

Equipment will be installed according to manufacturer specifications and meet all applicable codes.

Equipment will be installed to permit adequate air flow.

Equipment will have a timer for off-peak operation if time-of-use program is available and if the equipment can handle power interruptions.

Any penetrations to the exterior of the home created

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39 ASTM E241 - 09
40 NFPA 70A

Reduce or retire dehumidifiers

Reduce allergens and asthma triggers, improve health and reduce irritants

Improve building durability

Improve comfort

Reduce pest populations

Reduce risk of mold issues

Educate occupant on how to operate and maintain equipment
by the installation of the appliance will be sealed

Initial relative humidity and temperature settings will be set by the installer to ensure the space does not reach dew point

Operation of controls will be reviewed with occupant and will be labeled to achieve best performance

A user guide for humidifier settings in different climate conditions will be created by the installer and provided to the occupant

Installer will commission the equipment to ensure it is functioning properly

An independent measurement will be made to verify relative humidity

Installer will demonstrate proper disposal of water to avoid moisture issues

Specific information on the proper maintenance of the equipment will be provided to the occupant

Warranty information, operation manuals and installer contact information will be provided to the occupant
| 3 | Decommissioning | Prevent the reuse of inefficient equipment and its components  
|   | Removed equipment will be recycled or disposed of properly  
|   | Reduce waste  
|   | Protect environment |
**Topic: Baseload**  
**Subtopic: Plug Load**

9) **Detail Name:** Removal of Electrically Heated Waterbed Mattress

**Desired Outcome:**
- Energy used to heat a water bed reduced while maintaining occupant health and comfort

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Selection| Replacement materials will be selected that in no way compromise the health of the occupant or the occupant’s family (e.g., benefits from the heat, allergies to traditional bedding)  
If there is any indication that removal of the heated waterbed may cause health problems, it will not be replaced unless written approval is obtained from the occupant’s doctor  
Barring any health effects, acceptable options for replacement materials include one of the following:  
A non-heated waterbed, sized to fit the existing frame  
OR  
A conventional mattress, sized with 1” clearance to allow sheets to be changed  
OR  
Replacing the entire bed and mattress  
Materials selected will be acceptable to the occupant in | Ensure occupant satisfaction with new mattress  
Reduce energy use |
<table>
<thead>
<tr>
<th>No</th>
<th>Section</th>
<th>Description</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Installation</td>
<td>Old waterbed will be drained in a safe manner to a sewage drain without creating water damage to the house. Replacement will be installed in a location acceptable to the occupant.</td>
<td>Ensure home is not damaged and occupant is satisfied with the bed’s location.</td>
</tr>
<tr>
<td>3</td>
<td>Decommissioning</td>
<td>Materials will be recycled or disposed of properly.</td>
<td>Reduce pollution.</td>
</tr>
</tbody>
</table>
## Topic: Baseload
### Subtopic: Plug Load

### 10) Detail Name: Regional Considerations

<table>
<thead>
<tr>
<th>Row</th>
<th>Region</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very Cold</td>
<td>On demand water heaters will be sized to meet the demand of water flow at very low water intake temperatures[^41]</td>
<td>Provide adequate hot water to ensure occupant comfort</td>
</tr>
<tr>
<td>2</td>
<td>Cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Mixed Humid</td>
<td>Metal pipe will be used when venting dryers[^42]</td>
<td>Ensure proper dryer flow rate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rupture resistant hoses shall be used on all washer installations</td>
<td>Avoid moisture damage to the home from bursting water lines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All dehumidifier condensate drains will be hard piped to the outside[^43]</td>
<td>Ensure condensate does not leak into living space</td>
</tr>
<tr>
<td>4</td>
<td>Hot Humid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Marine</td>
<td>Dryers will be vented to outside of building[^44]</td>
<td>Ensure moisture vapor is removed from the home</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Homeowners will be discouraged from storing large amounts of firewood in the living space</td>
<td>Reduce the amount of interior moisture</td>
</tr>
<tr>
<td>6</td>
<td>Hot Dry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[^41]: NFPA 54, ANSI/AGA Z223.1  
[^42]: Standard 62.2-2010  
[^43]: Standard 62.2-2010  
[^44]: Standard 62.2-2010
Water Heating

Energy Use:
11) Water Heater Selection
12) Shower Head and Faucet Aerator

Installation and Replacement:
13) Storage Type Appliance
14) On Demand Appliance
15) Regional Considerations

Routine Maintenance:
16) Storage Type Appliance
17) On Demand Appliance
**Topic: Water Heating**  
**Subtopic: Energy Use**

11) **Detail Name: Water Heater Selection**

**Desired Outcome:**
- Safe and reliable hot water source selected that meets occupant needs at lowest possible cost of ownership

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Selection parameters</td>
<td>Equipment will provide sufficient, affordable, safe and healthy hot water for occupant</td>
<td>Save energy and water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potential for solar or other renewable systems will be assessed in selecting the hot water equipment</td>
<td>Protect the environment</td>
</tr>
</tbody>
</table>
|     |                      | Potential for health and safety hazards (e.g., backdrafting, flame rollout, obstructions) will be assessed in selecting equipment and the cost of remedying such problems will be included in any cost and benefit calculations  

If a combustion-based system is selected, it will be either direct vented or power vented

If combustion equipment is selected, a low nitrogen oxide burner will be included

Equipment will be functional at high efficiency under all conditions.                                                                                                                                                                                                                                                                                                                                 |

---

load conditions

Standby losses will be reduced to maximum potential

Fuel type will be selected based on affordability to occupant

Equipment will be freeze resistant

Efficiency of equipment will be maintained throughout life of system

Occupant control of hot water temperature will be provided on the equipment

The following will be determined from the occupant:

- Lifestyle
- Current and future needs
- Space considerations
- Fuel options
- Health and safety considerations
- Appliance options
- Maintenance and operation costs
- Return on investment concerns
|   | Product selection | A water heating appliance will be selected based on information from the occupant and desired specifications | Ensure equipment meets the occupant’s expectations while providing efficient energy and water use |
**Topic: Water Heating**

**Subtopic: Energy Use**

12) **Detail Name:** Shower Head and Faucet Aerator

**Desired Outcome:**
- Energy and water use reduced while occupant needs for water flow maintained

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Selection</td>
<td>Shower head flow rate will be 1.75 gallons per minute (GPM) or less</td>
<td>Reduce water and energy consumption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If multiple heads are provided, the total flow rate will not exceed 3.5 GPM</td>
<td>Ensure occupant satisfaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aerator flow rate will be 1.2 GPM or less</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Features will be selected that meet the special needs of the occupant (e.g., shut off, swivel, handheld showers)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Installation</td>
<td>Equipment will be installed according to manufacturer specifications and meet all applicable building codes</td>
<td>Reduce water and energy consumption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water quality will be evaluated for debris that may clog the equipment</td>
<td>Ensure occupant satisfaction with water flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plumbing will be evaluated to determine if the installation of high-efficiency shower heads or faucet aerators will cause leaks</td>
<td>Eliminate water leakage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If needed, plumbing will be corrected before installing</td>
<td>Prevent water damage</td>
</tr>
<tr>
<td>3</td>
<td>Decommissioning</td>
<td>Replaced shower head will be recycled or disposed of properly</td>
<td>Prevent the reuse of inefficient equipment and components</td>
</tr>
</tbody>
</table>

- high-efficiency shower head or faucet
- If needed, shower diverter will be repaired or replaced
- Any penetrations to the exterior of the home created by the installation of the equipment will be sealed
- Any damage done to the house during installation will be repaired
- Specific information about proper maintenance of the equipment will be provided to the occupant
- Warranty information, operation manuals and installer contact information will be provided to the occupant
- Water flow that satisfies the occupant will be provided by all shower heads and faucet aerators
- Occupant’s acceptance of the shower head or aerator will be documented
**Topic: Water Heating**  
**Subtopic: Installation and Replacement**

13) **Detail Name:** Storage Type Appliance

**Desired Outcome:**
- Safe and reliable hot water source provided that meets occupant needs at lowest possible cost of ownership

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
</table>
| 1   | Hazardous material removal   | Health concerns in the removal and replacement of equipment (e.g., asbestos, other hazardous materials) will be identified  
Written notification will be provided to occupants of the discovery of hazardous material, including contact information for regional EPA asbestos coordinator  
Occupant will be asked to contract with an EPA-certified asbestos contractor to conduct abatement before equipment removal and replacement (occupant is responsible for abatement or remediation) | Remediate health hazards using EPA-certified contractors                                          |
| 2   | Equipment removal            | Accepted industry procedures and practices will be followed to:  
- Remove old water heater and associated components | Ensure the safety of the workers and occupants  
Ensure building integrity  
Remove old equipment in a timely and efficient manner                                             |
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>New equipment installation</td>
<td>New water heater and associated components will be installed according to accepted industry standards and practices and manufacturer specifications. The system will be installed to be freeze-resistant. Any existing water leaks will be repaired before installation begins. Any penetrations to the exterior of the home created by the installation of the equipment will be sealed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ensure the safety of the workers and occupants. Ensure building integrity. Remove old equipment in a timely and efficient manner.</td>
</tr>
<tr>
<td>4</td>
<td>Emergency drain pan</td>
<td>An emergency drain pan will be installed a minimum of 4” above floor. A ¾” drain line or larger will be connected to tapping on pan and run to drain or pumped to daylight.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collect and safely dispose of water escaping from the storage tank.</td>
</tr>
</tbody>
</table>

46 ASTM C1193 - 09  
47 NFPA 54, ANSI, AGA Z223.1  
48 NFPA 54, ANSI, AGA Z223.1  
49 ASTM C1193 - 09
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Details</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Expansion tank</td>
<td>A stainless steel bladder expansion tank will be installed on the cold water side.</td>
<td>Protect the storage tank from expansion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A direct connection with no valves between the storage tank and expansion tank will be installed.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Temperature and pressure relief valve</td>
<td>Correct temperature and pressure relief valve will be installed according to manufacturer specifications</td>
<td>Discharge excessive energy (pressure or temperature) from storage tank to safe location</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Temperature and pressure relief valve discharge tube will terminate within 6” of the floor, or as prescribed by local code</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Di-electric unions</td>
<td>Di-electric unions will be installed according to manufacturer specifications</td>
<td>Break the stray voltage electrical circuit through the storage tank</td>
</tr>
<tr>
<td>8</td>
<td>Backflow prevention</td>
<td>Backflow prevention will be installed according to manufacturer specifications and all applicable codes</td>
<td>Protect the water supply from contamination</td>
</tr>
<tr>
<td>9</td>
<td>Thermal efficiency</td>
<td>Additional tank insulation (R-11) will be provided when necessary and where not prohibited by manufacturer</td>
<td>Reduce standby loss from near tank piping and storage tank</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If additional insulation is installed, it will be installed based on fuel type, making sure not to obstruct draft diverter, pressure relief valve, thermostats, hi-limit switch, plumbing pipes or elements</td>
<td>Ensure insulation does not make contact with flue gas venting</td>
</tr>
</tbody>
</table>

50 NFPA 54, ANSI, AGA Z223.1  
51 NFPA 54, ANSI, AGA Z223.1  
52 NFPA 54, ANSI, AGA Z223.1  
53 NFPA 54, ANSI, AGA Z223.1
<p>| | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>and thermostat access plates The first 6’ of inlet and outlet piping will be insulated according to manufacturer specifications Pipe insulation must remain 3” from gas water heater vent Heat traps will be installed on the inlet and outlet piping where not provided by manufacturer</td>
</tr>
<tr>
<td>10</td>
<td><strong>Required combustion air</strong></td>
<td>The volume of air required for complete combustion of the fuel and air mixture will be calculated in cubic feet per minute (CFM) and will meet the levels established by ANSI and NFPA. Additional combustion air will be provided according to ANSI and NFPA guidelines</td>
</tr>
<tr>
<td>11</td>
<td><strong>Venting of flue gases</strong> 55</td>
<td>Combustion byproducts will be removed as per Section 504 IFGC for gas water heaters or NFPA 31 for oil water heaters</td>
</tr>
<tr>
<td>12</td>
<td><strong>Combustion testing</strong> 56</td>
<td>Undiluted flue gases will be checked with a calibrated flue gas analyzer according to accepted protocol If combustion is not happening safely or to maximum efficiency, diagnostics and adjustments will be done according to manufacturer specifications and local codes</td>
</tr>
</tbody>
</table>

54 NFPA 54, ANSI, AGA Z223.1
55 NFPA 54, ANSI, AGA Z223.1 or NFPA 31
56 ASTM E 1198-02 2007
| 13 | Fuel supply | Electric or fossil fuel supply components will be installed to accepted industry standards as per NFPA 31 for oil or NEC for electric\(^{57}\) | Provide sufficient fuel to the water heater, burner and or element |
| 14 | Discharge temperature | Discharge temperature will be set to not exceed 120° or as prescribed by local code | Ensure safe hot water supply temperature to fixtures |
| 15 | Commissioning of system | The following will be checked once the system has been filled and purged:\(^{58}\)  
- Safety controls  
- Combustion safety and efficiency  
- Operational controls  
- Fuel and water leaks  
- Local code requirements | Ensure safe system function  
Keep cost of ownership as low as possible |
| 16 | Occupant health and safety | In the case of fossil fuel installations, carbon monoxide (CO) monitors will be installed in all homes where none are present\(^{59}\)  
On completion of work, ambient CO will be tested to verify level does not exceed industry accepted levels | Protect occupant health and safety |

\(^{57}\) NFPA 54, ANSI, AGA Z223.1 or NFPA 31 or NFPA 70A  
\(^{58}\) NFPA 54, ANSI, AGA Z223.1 or NFPA 31 or NFPA 70A  
\(^{59}\) NFPA 720
|   | **Occupant education**<sup>60</sup> | Completed work will be reviewed  
Occupants will be educated on the safe and efficient operation and maintenance of the system, including:  
- Adjustment of water temperature and target temperature per local code  
- Periodic drain and flush  
- Expansion tank and backflow preventer (no occupant maintenance required)  
- Periodic inspection, maintenance or replacement | Ensure occupant is informed of the safe, efficient operation and maintenance of the system |

---

<sup>60</sup> ANSI,ASHRAE Standard 62.2-2010
### Topic: Water Heating
#### Subtopic: Installation and Replacement

14) **Detail Name:** On Demand Appliance

**Desired Outcome:**
- Safe and reliable hot water source provided that meets occupant needs at lowest possible cost of ownership

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hazardous material removal</td>
<td>Health concerns in the removal and replacement of equipment (e.g., asbestos, other hazardous materials) will be identified&lt;br&gt;Written notification will be provided to occupants of the discovery of hazardous material, including contact information for regional EPA asbestos coordinator&lt;br&gt;Occupants will be asked to contract with an EPA-certified asbestos contractor to conduct abatement before equipment removal and replacement (occupant is responsible for abatement or remediation)</td>
<td>RemEDIATE health hazards using EPA-certified contractors</td>
</tr>
<tr>
<td>2</td>
<td>Equipment removal</td>
<td>Accepted industry procedures and practices will be followed to:&lt;br&gt;- Remove old water heater and associated components</td>
<td>Ensure the safety of the workers and occupants&lt;br&gt;Ensure building integrity while timely and efficiently removing old equipment</td>
</tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>New equipment installation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A new water heater and associated components will be installed to accepted industry standards and practices, and according to manufacturer specifications.</td>
<td>Ensure the safety of the workers and occupants. Ensure building integrity while installing new equipment in a timely and efficient manner.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><strong>Emergency drain pan</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>An emergency drain pan will be installed according to the following criteria:</td>
<td>Collect and safely dispose of water escaping from the storage tank.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• A minimum of 4” above floor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Connected to ¾” drain line or larger to tapping on pan</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Run to drain, pump or daylight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><strong>Temperature and pressure relief valve</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Correct temperature and pressure relief valve will be installed according to manufacturer specifications.</td>
<td>Discharge excessive energy (pressure or temperature) from storage tank to safe location.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Equipment will be connected to properly sized discharge tube and run to a safe location no greater than 6” from floor or as prescribed by local code.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

61 ASTM C1193 - 09
62 NFPA 54, ANSI, AGA Z223.1 or NFPA 31 or NFPA 70A
63 NFPA 54, ANSI, AGA Z223.1
<table>
<thead>
<tr>
<th></th>
<th><strong>Di-electric unions</strong></th>
<th><strong>Backflow prevention and pressure regulator</strong></th>
<th><strong>Thermal efficiency</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Di-electric unions will be installed according to manufacturer specifications</td>
<td>Backflow prevention will be installed according to manufacturer specifications</td>
<td>Any accessible hot water lines will be insulated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>House water pressure and volume will be verified as sufficient to meet appliance manufacturer specifications</td>
<td>Reduce line losses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All applicable codes will be followed</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Thermal efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td><strong>Required combustion air</strong></td>
<td>Recommendations will be made to install all on-demand appliances as sealed combustion</td>
<td>Ensure adequate combustion air for operation of the appliance</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>If not possible:</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Required volume of air required for complete combustion of the fuel/air mixture will be calculated in cubic feet per minute (CFM) as established by ANSI and NFPA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Additional combustion air will be provided according to ANSI and NFPA guidelines</td>
<td></td>
</tr>
</tbody>
</table>

64 NFPA 70A  
65 NFPA 54, ANSI, AGA Z223.1  
66 ANSI, ASHRAE Standard 90.2-2007
| 10 | Venting of flue gases | Combustion byproducts will be removed as per Section 504 IFGC for gas water heaters or NFPA 31 for oil water heaters | Ensure the safety and durability of the venting system |
| 11 | Combustion testing | Undiluted flue gases will be checked with a calibrated flue gas analyzer according to accepted protocol. If combustion is not happening safely or to maximum efficiency, diagnostics and adjustments will be done according to manufacturer specifications or local codes. | Confirm that combustion is occurring safely with maximum efficiency |
| 12 | Fuel supply | Electric or fossil fuel supply components will be installed to accepted industry standards as per NFPA 31 for oil or NEC for electric. Energy input required by the appliance will meet manufacturer specifications. | Provide sufficient fuel to the water heater burner or element |
| 13 | Cold water supply | The volume and pressure of the water supplied to the appliance will meet manufacturer specifications. | Provide sufficient volume and pressure of water to the appliance |
| 14 | Discharge temperature | Discharge temperature will be set not to exceed 120° or as per local code, whichever is lower. | Ensure safe hot water supply temperature to fixtures |
| 15 | Commissioning of system | The following will be checked once the system has been connected and filled: Safety controls. | Ensure system functions safely with lowest possible cost of ownership |

67 NFPA 54, ANSI, AGA Z223.1 or NFPA 31
69 NFPA 54, ANSI, AGA Z223.1 or NFPA 31 or NFPA 70A
70 NFPA 54, ANSI, AGA Z223.1
71 NFPA 54, ANSI, AGA Z223.1 or NFPA 31 or NFPA 70A
| 16 | Ambient carbon monoxide (CO) | CO monitors will be installed in all homes where none are present.  
On completion of work, ambient CO will be tested to verify level does not exceed industry accepted levels |
| 17 | Occupant education | Completed work will be reviewed  
Occupants will be educated on the safe and efficient operation and maintenance of the system, including:  
- Adjustment of water temperature and target temperature per local code  
- Operation of backflow preventer and pressure regulator (no occupant maintenance required) |

- Combustion safety and efficiency  
- Operational controls  
- Fuel and water leaks  
- Cycle unit  
- Local code requirements

Manufacturer specifications and all relevant industry standards will be met in commissioning

Protect occupant health and safety

Ensure occupant is informed of the safe, efficient operation and maintenance of the system

72 NFPA 720  
73 ANSI,ASHRAE Standard 62.2-2010
- Importance of keeping operating manuals accessible
### Topic: Water Heating
**Subtopic:** Installation and Replacement

15) **Detail Name:** Regional Considerations

<table>
<thead>
<tr>
<th>Row</th>
<th>Region</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very Cold</td>
<td>On-demand water heaters will be sized to meet the demand of water flow at very low water intake temperatures (^{74})</td>
<td>Ensure occupant comfort by providing adequate hot water</td>
</tr>
<tr>
<td>2</td>
<td>Cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Mixed Humid</td>
<td>Insulation will be installed when water heater is located in unconditioned space</td>
<td>Avoid energy loss</td>
</tr>
<tr>
<td>4</td>
<td>Hot Humid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Marine</td>
<td>Hurricane and earthquake straps will be installed on all water heaters</td>
<td>Ensure the durability and proper operation of the water heating system</td>
</tr>
<tr>
<td>6</td>
<td>Hot Dry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{74}\) NFPA 54, ANSI, AGA Z223.1
**Topic: Water Heating**  
**Subtopic:** Routine Maintenance

16) **Detail Name:** Storage Type Appliance

**Desired Outcome:**
- Safe, reliable and efficient operation of the appliance maintained

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Health and safety</td>
<td>The Building Performance Institute (BPI) protocol or equivalent for Combustion Appliance Zone (CAZ) combustion safety testing will be administered</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>NEC violations (e.g., no electrical box connector, no disconnect, improperly sized breaker and wire) will be addressed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identify potential health and safety issues</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Visual inspection</td>
<td>Inspection will be conducted to find the following:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Water or fuel leaks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Damaged or missing pipe insulation, and tank insulation where applicable</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Damaged wiring</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Venting issues with draft and condensation (e.g., soot, rusting of flue pipe, burned paint or wires, efflorescence)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Determine needed repairs or maintenance</td>
<td></td>
</tr>
</tbody>
</table>

75 ASTM E1998 - 02(2007)  
76 NFPA 70A  
77 NFPA 54,ANSI,AGA Z223.1
<p>| | | |</p>
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<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Corrosion (e.g., rust, mineral deposits)</strong></td>
<td></td>
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<td><strong>General condition of components</strong></td>
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<td><strong>Tanks will be insulated to a minimum of R-11 unless prohibited by codes or the manufacturer</strong></td>
<td><strong>Reduce standby losses from near tank piping and storage tank</strong></td>
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<td></td>
<td>Added insulation will not obstruct the unit’s draft diverter, pressure relief valve, thermostats, hi-limit switch, plumbing pipes or elements and thermostat access plates</td>
<td>Ensure insulation does not make contact with flue gas venting</td>
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<td>The first 6’ of inlet and outlet piping will be insulated according to manufacturer specifications</td>
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<td>3</td>
<td><strong>Thermal efficiency</strong></td>
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<td>A stainless steel bladder expansion tank will be installed on the cold water side</td>
<td><strong>Absorb water expansion of the system</strong></td>
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<td>A direct connection with no valves from the expansion tank to the storage tank will be installed</td>
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<td>Connection will be properly supported with strapping</td>
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<td>Tanks that leak or have excessive corrosion will be replaced</td>
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<td>An expansion tank drain will be included in non-bladder</td>
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<td>4</td>
<td><strong>Stainless steel expansion tank</strong></td>
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78 NFPA 54, ANSI, AGA Z223.1
79 NFPA 54, ANSI, AGA Z223.1
<table>
<thead>
<tr>
<th>5</th>
<th>Temperature and pressure relief valve</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Correct temperature and pressure relief valve will be installed according to manufacturer specifications</td>
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<tr>
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<td>Equipment will be connected to properly sized discharge tube</td>
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<td></td>
<td>Discharge tube will be run to a safe location no greater than 6” from floor or as prescribed by local code</td>
</tr>
</tbody>
</table>

80 NFPA 54, ANSI, AGA Z223.1  
81 NFPA 54, ANSI, AGA Z223.1  
82 NFPA 54, ANSI, AGA Z223.1
<table>
<thead>
<tr>
<th></th>
<th>Maintenance records</th>
<th>Occupants will be advised to keep records of all maintenance done to their system. Copies of or access to installation and operation manuals will be provided</th>
<th>Provide a history of system installation and maintenance to improve chance of successful future maintenance or repair</th>
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<tbody>
<tr>
<td>8</td>
<td>Occupant health and safety</td>
<td>Carbon monoxide (CO) monitors will be installed in all homes where none are present. On completion of work, ambient CO will be tested to verify level does not exceed industry accepted levels</td>
<td>Protect occupant health and safety</td>
</tr>
</tbody>
</table>
| 9 | Occupant education | Completed work will be reviewed. Occupants will be educated on the safe and efficient operation and maintenance of the system, including:  
  • Adjustment of water temperature and target temperature per local code  
  • Periodic drain and flush  
  • Periodic inspection, maintenance or replacement of Anode rod | Ensure occupant is informed of the safe, efficient operation and maintenance of the system |

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83 NFPA 54, ANSI, AGA Z223.1  
84 NFPA 720  
85 ANSI, ASHRAE Standard 90.2-2007
## Topic: Water Heating

### Subtopic: Routine Maintenance

**17) Detail Name:** On Demand Appliance

**Desired Outcome:**
- Safe, reliable and efficient operation of the appliance maintained

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Health and safety</td>
<td>The Building Performance Institute (BPI) protocol or equivalent for Combustion Appliance Zone (CAZ) combustion safety testing will be administered (^{86}) Violations of National Electric Code (e.g., no electrical box connector, no disconnect, improperly sized breaker and wire) will be addressed (^{87})</td>
<td>Identify potential health and safety issues</td>
</tr>
<tr>
<td>2</td>
<td>Visual inspection</td>
<td>Components will be inspected for the following: (^{88}) Water or fuel leaks, Damaged or missing pipe insulation, Damaged wiring, Venting Issues – draft and condensation (e.g., soot, rusting of flue pipe, burned paint or wires, efflorescence)</td>
<td>Determine needed repairs or maintenance</td>
</tr>
</tbody>
</table>

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\(^{86}\) ASTM E1998 - 02(2007)  
\(^{87}\) NFPA 70A  
\(^{88}\) NFPA 54, ANSI, AGA Z223.1
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<td>• Additional combustion air will be provided according to ANSI and NFPA guidelines</td>
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<td>6</td>
<td>Venting of flue gases</td>
<td>Condition of venting will be inspected per Section 504 IFGC for gas water heaters or NFPA 31 for oil water heaters</td>
</tr>
<tr>
<td>7</td>
<td>Fuel supply</td>
<td>Condition of fuel supply components will be checked per NFPA 31 for oil or NEC for electric</td>
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<tr>
<td>8</td>
<td>Cold water supply</td>
<td>Water supplied to the appliance will be of sufficient volume and pressure to meet manufacturer specifications</td>
</tr>
<tr>
<td>9</td>
<td>Discharge temperature</td>
<td>Discharge temperature will be set not to exceed 120° or as per local code, whichever is lower</td>
</tr>
</tbody>
</table>
| 10 | Test the system safety and operational | The following will be tested:  
• Safety controls (e.g., water and air pressure switches)  
• Combustion safety and efficiency  
• Operational controls  
• Fuel and water leaks  
• Unit runs through complete cycle  
• Local code requirements | Ensure system functions safely with lowest possible cost of ownership |

92 NFPA 31 or NFPA 54, ANSI, AGA Z223.1  
93 NFPA 54, ANSI, AGA Z223.1 or NFPA 31 or NFPA 70A
<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Manufacturer specifications and all relevant industry standards will be met</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>11</strong></td>
<td><strong>Maintenance records</strong></td>
</tr>
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<td><strong>12</strong></td>
<td><strong>Occupant health and safety</strong></td>
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<td><strong>13</strong></td>
<td><strong>Occupant education (^96)</strong></td>
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\(^{94}\) ANSI,ASHRAE Standard 62.2-2010  
\(^{95}\) NFPA 720  
\(^{96}\) ANSI,ASHRAE Standard 62.2-2010
Shading

Landscaping:

18) Indigenous Shading
Topic: Shading
Subtopic: Landscaping

18) Detail Name: Indigenous Shading

Desired Outcome:
- Heat gain reduced through use of indigenous shade plants

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Plant selection</td>
<td>All plantings intended for shading will be indigenous and drought resistant</td>
<td>Ensure plantings survive in local conditions using a minimum amount of water</td>
</tr>
<tr>
<td>2</td>
<td>Size</td>
<td>No planting will be chosen that will grow to a height that would cause damage to the house if it or any part of it fell on the house</td>
<td>Reduce the possibility of damage to the house</td>
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# GLOSSARY

<table>
<thead>
<tr>
<th>Row</th>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ACCA</td>
<td>Air Conditioning Contractors of America, <a href="http://www.acca.org">www.acca.org</a></td>
</tr>
<tr>
<td>2</td>
<td>ADC</td>
<td>Air Diffusion Council, <a href="http://www.flexibleduct.org">www.flexibleduct.org</a></td>
</tr>
<tr>
<td>3</td>
<td>Air barrier</td>
<td>The separation between the interior and exterior environments of a building that slows air flow to the point that no smoke movement is visible at 50 Pascals of pressure difference across the boundary</td>
</tr>
<tr>
<td>4</td>
<td>ANSI</td>
<td>American National Standards Institute, <a href="http://www.ansi.org">www.ansi.org</a></td>
</tr>
<tr>
<td>7</td>
<td>Backdraft damper</td>
<td>A damper that allows air to flow in only one direction</td>
</tr>
<tr>
<td>8</td>
<td>Beaded collar</td>
<td>A round fitting with a ridge or lip partway down its length that prevents a flexible duct that is mechanically attached with a draw band from sliding off</td>
</tr>
<tr>
<td>9</td>
<td>Bonus room</td>
<td>A livable room that is often over a garage or in an attic area; the room commonly contains slanted ceilings and knee walls</td>
</tr>
<tr>
<td>10</td>
<td>BPI</td>
<td>Building Performance Institute, <a href="http://www.bpi.org">www.bpi.org</a></td>
</tr>
<tr>
<td>11</td>
<td>Can light</td>
<td>A light fixture (or can) that is recessed into the ceiling</td>
</tr>
<tr>
<td>12</td>
<td>Cathedral ceiling</td>
<td>A condition in which the ceiling has the same slope as the roof</td>
</tr>
<tr>
<td>13</td>
<td>Cathedralized attic</td>
<td>An attic that contains insulation located at the roof deck rather than the attic floor, bringing the attic space into the thermal boundary of the house</td>
</tr>
<tr>
<td></td>
<td>Definition</td>
<td>Details</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>14</td>
<td>Closed crawl space</td>
<td>A foundation without wall vents that uses air-sealed walls, ground and foundation moisture control, and mechanical drying method to control crawl space moisture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation may be located at the conditioned floor level or on the exterior walls</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Return pathways are not allowed from the crawl space to the living space</td>
</tr>
<tr>
<td>15</td>
<td>Conditioned crawl space</td>
<td>A foundation without wall vents that encloses an intentionally heated and/or cooled space</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation is located on the exterior walls</td>
</tr>
<tr>
<td>16</td>
<td>Conditioned basement</td>
<td>A below- or partially below-grade livable space with concrete or finished floor that is intentionally heated or cooled</td>
</tr>
<tr>
<td>17</td>
<td>Dense pack</td>
<td>The process of installing loose-fill insulation to reduce air flow and perform to a stated R-value</td>
</tr>
<tr>
<td>18</td>
<td>Di-electric union</td>
<td>A plumbing connection that separates two different materials and does not allow them to chemically react and break down</td>
</tr>
<tr>
<td>19</td>
<td>Tie band</td>
<td>A strap, often made of nylon, that mechanically squeezes a flexible duct to a fitting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Must have a minimum performance temperature rating of 165° (per UL 181A-type test) and a minimum tensile strength rating of 50 pounds</td>
</tr>
<tr>
<td>20</td>
<td>Efflorescence</td>
<td>Deposits of crystals or salts left attached to masonry materials after moisture has evaporated off of the surface</td>
</tr>
<tr>
<td>21</td>
<td>Egress window</td>
<td>A window that people can escape through in an emergency</td>
</tr>
<tr>
<td>22</td>
<td>Envelope</td>
<td>The separation between the interior and exterior environments of a building, which includes a combination of air and thermal barriers</td>
</tr>
<tr>
<td>23</td>
<td>EPA</td>
<td>Environmental Protection Agency, <a href="http://www.epa.gov">www.epa.gov</a></td>
</tr>
<tr>
<td>24</td>
<td>Exfiltration</td>
<td>The uncontrolled passage of inside air out of a building through unintended leaks in the building envelope</td>
</tr>
<tr>
<td>25</td>
<td>Exterior storm window</td>
<td>An additional window assembly installed on the exterior of the main window</td>
</tr>
<tr>
<td></td>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>26</td>
<td>Finished attic</td>
<td>An attic space which has been converted into an additional living space of the house</td>
</tr>
<tr>
<td>27</td>
<td>Hi-limit switch</td>
<td>A protective electronic switch that keeps a burner from continuing to operate and damage the appliance</td>
</tr>
<tr>
<td>28</td>
<td>Hydrophobic</td>
<td>Lacking affinity for water; tending to repel and not absorb water; tending not to dissolve in, mix with or be wetted by water</td>
</tr>
<tr>
<td>29</td>
<td>IBR</td>
<td>Institute of Boiler and Radiator Manufacturers, <a href="http://www.gamanet.org">www.gamanet.org</a></td>
</tr>
<tr>
<td>30</td>
<td>IECC</td>
<td>International Energy Conservation Code</td>
</tr>
<tr>
<td>31</td>
<td>Ignition barrier</td>
<td>Any layer of material that protects another from catching fire due to heat or spark</td>
</tr>
<tr>
<td>32</td>
<td>IMC</td>
<td>International Mechanical Code</td>
</tr>
<tr>
<td>33</td>
<td>Infiltration</td>
<td>The uncontrolled passage of outside air into a building through unintended leaks in the building envelope</td>
</tr>
<tr>
<td>34</td>
<td>Interior storm window</td>
<td>An additional window assembly installed on the interior of the main window</td>
</tr>
<tr>
<td>35</td>
<td>IRC</td>
<td>International Residential Code</td>
</tr>
<tr>
<td>36</td>
<td>Knee wall</td>
<td>Any wall between the conditioned space and the attic</td>
</tr>
<tr>
<td>37</td>
<td>Modulating systems</td>
<td>Heating systems with the ability to adjust the heating capacity and output based on the heating demand</td>
</tr>
<tr>
<td>40</td>
<td>NEBB</td>
<td>National Environmental Balancing Bureau, <a href="http://www.nebb.org">www.nebb.org</a></td>
</tr>
<tr>
<td>41</td>
<td>NEC</td>
<td>National Electrical Code</td>
</tr>
<tr>
<td>43</td>
<td>Orphaned equipment</td>
<td>Condition when one smaller combustion appliance exists after being commonly vented with a larger appliance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What remains is a larger exhaust flue or chimney than is necessary for the remaining smaller appliance</td>
</tr>
<tr>
<td></td>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>---</td>
<td>---------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>44</td>
<td>Orphaned water heater</td>
<td>Condition when one smaller combustion appliance (i.e. water heater) exists after being commonly vented with a larger appliance. What remains is a larger exhaust flue or chimney than is necessary for the water heater.</td>
</tr>
<tr>
<td>45</td>
<td>OSHA</td>
<td>Occupational Safety and Health Administration, <a href="http://www.osha.gov">www.osha.gov</a></td>
</tr>
<tr>
<td>46</td>
<td>Perm rating</td>
<td>The measurement of a material’s ability to allow the transfer of water vapor through the material.</td>
</tr>
<tr>
<td>47</td>
<td>Programmable thermostat</td>
<td>A thermostat designed to adjust the temperature according to a series of programmed settings that take effect at different times of the day.</td>
</tr>
<tr>
<td>48</td>
<td>Rigid material</td>
<td>Drywall, oriented strand board, duct board, cardboard or any other stiff product that may support the load of insulation while serving as a durable air barrier.</td>
</tr>
<tr>
<td>49</td>
<td>RPA</td>
<td>Radiant Panel Association, <a href="http://www.radiantpanelassociation.org">www.radiantpanelassociation.org</a></td>
</tr>
<tr>
<td>50</td>
<td>Service switch</td>
<td>An electrical switch that controls the complete flow of electricity to a mechanical device.</td>
</tr>
<tr>
<td>51</td>
<td>SMACNA</td>
<td>Sheet Metal and Air Conditioning Contractors’ National Association, <a href="http://www.smacna.org">www.smacna.org</a></td>
</tr>
<tr>
<td>52</td>
<td>Standby loss</td>
<td>Heat loss through the outer part of a water heater. Energy that is used even when that device is turned off.</td>
</tr>
<tr>
<td>53</td>
<td>Storm door</td>
<td>An additional door assembly that is installed on the exterior of the main door.</td>
</tr>
<tr>
<td>54</td>
<td>Strip heat</td>
<td>A function of a heat pump that uses energy-intensive resistance heat to warm conditioned space when the heat pump is unable to satisfy the heating demand; also provides emergency heat backup for heat pumps.</td>
</tr>
<tr>
<td>55</td>
<td>TABB</td>
<td>Testing and Balancing Bureau, <a href="http://www.tabcertified.org">www.tabcertified.org</a></td>
</tr>
<tr>
<td>56</td>
<td>Thermal boundary</td>
<td>The separation between the interior and exterior environments of a building that slows heat flow.</td>
</tr>
<tr>
<td>57</td>
<td>Unconditioned basement</td>
<td>A below- or partially below-grade livable space with concrete or finished floor without intentional heating or cooling.</td>
</tr>
<tr>
<td></td>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>58</td>
<td>Thermal resistance</td>
<td>The insulation or other building material that offers the primary barrier to thermal transmittance. R-value is a measurement of thermal resistance.</td>
</tr>
<tr>
<td>59</td>
<td>Vapor barrier</td>
<td>A material that retards the passage of water vapor and contains a perm rating of less than 1.</td>
</tr>
<tr>
<td>60</td>
<td>Vapor retarder</td>
<td>A material that slows the passage of water vapor and contains a perm rating above 1.</td>
</tr>
<tr>
<td>61</td>
<td>Vaulted ceiling</td>
<td>A condition where the ceiling has a different slope than the roof.</td>
</tr>
<tr>
<td>62</td>
<td>Vented crawl space</td>
<td>A foundation that uses wall vents as a primary means to control moisture. Insulation is located at the conditioned floor level above the crawl space.</td>
</tr>
<tr>
<td>63</td>
<td>Wind intrusion</td>
<td>A condition where air from outside of a structure can pass through insulation and reduce its performance.</td>
</tr>
<tr>
<td>64</td>
<td>Wood/materials shrinkage</td>
<td>A loss of dimension and weight as a result of drying the structure and operating the building at lower relative humidity.</td>
</tr>
</tbody>
</table>
APPENDIX D

Referenced Standards
SUMMARY OF OSHA STANDARDS REFERENCED:
PERSONAL PROTECTIVE EQUIPMENT (PPE)
Personal Protective Equipment (CFR 1926.28 & Subpart E and 1910 Subpart I) General requirements (CFR 1926.95 and 1910.132)
- Eye and face protection (CFR 1926.102 and 1910.133)
- Respiratory Protection (CFR 1926.103 and 1910.134)
  - Fit Testing Procedures (CFR 1910.134 Appendix A – Mandatory)
- Head protection (CFR 1926.100 and 1910.135)
- Foot protection (CFR 1926.96 and 1910.136)
- Electrical protective devices (CFR 1910.137)

Electrical (CFR 1926 Subparts K & V and 1910 Subpart S)

Confined Space (CFR 1910.146)

Environmental Controls and Ventilation for Construction (CFR 1926 Subpart D and 1926.57)

Fire Safety (CFR 1926 Subpart F and 1910 Subpart L)

Fall Protection (CFR 1926 Subpart M)

Walking working surfaces (CFR 1910 Subpart D)

Flammable and Combustible Liquids (CFR 1926.152 and 1910.106)

General duty clause – Section 5 (a)(1) OSH Act

Compressed Gas and Compressed Air Equipment (CFR 1926.154 and 1910 Subpart M)

Hazardous materials (CFR 1910 Subpart H and 1910 Subpart H)

Egress (CFR 1926.34 and 1910 Subpart E)

Storage and Handling of Liquefied Petroleum Gases (CFR 1926.153 and 1910.110)

Hand and Portable Powered Tools and Other Hand-held Equipment (CFR 1926 Subpart I and 1910 Subpart P)

Welding and Brazing (CFR 1926 Subpart J and 1910 Subpart Q)

Toxic and Hazardous Materials (CFR 1926 Subpart Z and 1910 Subpart Z)

Hazardous Communications (CFR 1926.59 and 1910.1200)

Lockout and Tagging Circuits (CFR 1926.417)

Ladders (CFR 1926 Subpart X)
SUMMARY OF STANDARDS REFERENCED:

AIR SEALING

Significance and Use

Air infiltration into the conditioned space of a building accounts for a significant portion of the thermal space condition load. Air infiltration can affect occupant comfort by producing drafts, causing indoor air quality problems by carrying outdoor pollutants into occupied building space and, in hot humid climates, depositing moisture in the building envelope, resulting in deterioration of building envelope components. In cold climates, exfiltration of conditioned air out of a building can deposit moisture in the building envelope causing deterioration of building envelope components. Differential pressure across the building envelope and the presence of air leakage sites cause air infiltration and exfiltration (1).

In some buildings, restricting air movement between interior zones of a building may be desired to separate dissimilar interior environments or prevent the movement of pollutants. Although not dealt with specifically in this standard, the detection practices presented can also be useful in detecting air leaks between interior zones of the building.

Air leakage sites are often difficult to locate because air flows may be small under the prevailing weather conditions. Wind conditions can aid in air leakage detection by forcing air to enter a building; however, where air is exiting, the building envelope construction may make observations difficult. For these reasons, forced pressurization or depressurization is strongly recommended for those practices which require controlled flow direction.

The techniques for air leakage site detection covered in these practices allow for a wide range of flexibility in the choice of techniques that are best suited for detecting various types of air leakage sites in specific situations.

The infrared scanning technique for air leakage site detection has the advantage of rapid surveying capability. Entire building exterior surfaces or inside wall surfaces can be covered with a single scan or a simple scanning action, provided there are no obscuring thermal effects from construction features or incident solar radiation. The details of a specific air leakage site may then be probed more closely by focusing on the local area. Local leak detection is well addressed with smoke tracer, anemometer, sound detection, bubble detection, and tracer gas techniques. However, these techniques are time consuming for large surfaces. The pressurized or depressurized test chamber and smoke tracer or a depressurized test chamber and leak detection liquid practices can be used in situations where depressurizing or pressurizing the entire envelope is impractical, which is the case during construction. Both of the practices enable the detection of very small leaks. To perform these practices, the air barrier system must be accessible.

Complexity of building air leakage sites may diminish the ability for detection. For example, using the sound detection approach, sound may be absorbed in the tortuous path through the
insulation. Air moving through such building leakage paths may lose some of its temperature differential and thus make thermographic detection difficult. The absence of jet-like air flow at an air leakage site may make detection using the anemometer practice difficult.

Stack effect in multistory commercial buildings can cause gravity dampers to stand open. Computer-controlled dampers should be placed in normal and night modes to aid in determining existing building conditions. Sensitive pressure measurement equipment can be used for evaluating pressure levels between floors and the exterior. Monitoring systems in high-tech buildings can supply qualitative data on pressure differences.

1. Scope

1.1 These practices cover standardized techniques for locating air leakage sites in building envelopes and air barrier systems.

1.2 These practices offer choices for means of determining the location of air leakage sites with each offering certain advantages for specific applications.

1.3 Some of the practices require knowledge of infrared scanning, building and test chamber pressurization and depressurization, smoke generation techniques, sound generation and detection, and tracer gas concentration measurement techniques.

1.4 The practices described are of a qualitative nature in determining the air leakage sites rather than determining quantitative leakage rates.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific hazard statements, see Section 6.

Referenced Documents

ASTM Standards

E631 Terminology of Building Constructions
E741 Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution
E779 Test Method for Determining Air Leakage Rate by Fan Pressurization

Other Standards

ASTM C834 - 10 Standard Specification for Latex Sealants

Abstract

This specification covers latex sealants used for sealing joints in building construction. The following are the type and grade of sealant under this specification: Type OP, Type C, Grade 18°C, Grade 0°C and Grade NF. The sealant shall be composed of latex formulated with appropriate fillers, pigments and chemical additives. The physical properties of the sealant shall conform to the specified requirements according to type and grade. The following tests shall be done: extrudability after aging, artificial weathering, volume shrinkage, low-temperature flexibility, extension-recovery and adhesion, slump, staining and tack-free time.

This abstract is a brief summary of the referenced standard. It is only informational and not an official part of the standard; the full text of the standard itself must be referred to for its use and application. ASTM neither gives any warranty, expressed or implied, nor makes any representation that the contents of this abstract are accurate, complete or timely.

Significance and Use

This specification covers two types and three grades of latex sealants, as described in Section 4, that are formulated for general caulking and sealing operations in building construction. It should be recognized by the user that not all sealants meeting this specification are suitable for all applications and all substrates. It is essential, therefore, that the type and grade be specified for proper description of a sealant. Test methods relate to special standard substrates of glass, wood and aluminum. If tests are required using substrates in addition to or other than the standard, they should be so specified for testing.

Refer to Guide C1193 for information on the proper use of sealants meeting this specification.

1. Scope

1.1 This specification covers one component of latex sealants used for sealing joints in building construction.

1.2 A sealant meeting the requirements of this specification shall be classified by the manufacturer to be one of the types and grades defined in Section 4.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound in the parentheses is provided for informational purposes only.

1.4 The following precautionary caveat pertains only to the test method portion, Section 10, of this specification: This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.
Note 1—Currently, there is no ISO standard similar to this specification.

Referenced Documents

ASTM Standards
C717 Terminology of Building Seals and Sealants
C732 Test Method for Aging Effects of Artificial Weathering on Latex Sealants
C734 Test Method for Low-Temperature Flexibility of Latex Sealants After Artificial Weathering
C736 Test Method for Extension-Recovery and Adhesion of Latex Sealants
C1183 Test Method for Extrusion Rate of Elastomeric Sealants
C1193 Guide for Use of Joint Sealants
C1241 Test Method for Volume Shrinkage of Latex Sealants During Cure
D2202 Test Method for Slump of Sealants
D2203 Test Method for Staining from Sealants
D2377 Test Method for Tack-Free Time of Caulking Compounds and Sealants
ASTM E136 - 09b Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C

Significance and Use

While actual building fire exposure conditions are not duplicated, this test method will assist in indicating those materials which do not act to aid combustion or add appreciable heat to an ambient fire.

Materials passing the test are permitted limited flaming and other indications of combustion.

1. Scope

1.1 This fire-test-response evaluation method covers the determination under specified laboratory conditions of combustion characteristics of building materials.

1.2 Limitations of this test method are shown below.

1.2.1 This test method does not apply to laminated or coated materials.

1.2.2 This test method is not suitable or satisfactory for materials that soften, flow, melt, intumesce or otherwise separate from the measuring thermocouple.

1.2.3 This test method does not provide a measure of an intrinsic property.

1.2.4 This test method does not provide a quantitative measure of heat generation or combustibility; it simply serves as a test method with selected (endpoint) measures of combustibility.

1.2.5 This test method does not measure the self-heating tendencies of materials.

1.2.6 In this test method materials are not being tested in the nature and form used in building applications. The test specimen consists of a small, specified volume that is either (1) cut from a thick sheet; (2) assembled from multiple thicknesses of thin sheets; or (3) placed in a container if composed of granular powder or loose-fiber materials.

1.2.7 Results from this test method apply to the specific test apparatus and test conditions, and are likely to vary when changes are made to one or more of the following: (1) the size, shape and arrangement of the specimen; (2) the distribution of organic content; (3) the exposure temperature; (4) the air supply; (5) the location of thermocouples.

1.3 This test method references notes and footnotes that provide explanatory information. These notes and footnotes, excluding those in tables and figures, shall not be considered as requirements of this test method.
1.4 The values stated in SI units are to be regarded as the standard. The values given in the parentheses are for informational purposes only.

1.5 This standard is used to measure and describe the response of materials, products or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire-hazard or fire-risk assessment of the materials, products or assemblies under actual fire conditions.

1.6 Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.

1.7 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.

Referenced Documents

ASTM Standards
  D3174 Test Method for Ash in the Analysis Sample of Coal and Coke from Coal
  E84 Test Method for Surface Burning Characteristics of Building Materials
  E176 Terminology of Fire Standards

ISO Standard
  ISO 13943 Fire Safety-Vocabulary

Other Standard
  BS476 Combustibility Test of Materials

16CFR460.17 What installers must tell their customers
If you are an installer, you must give your customers a contract or receipt for the insulation you install. For all insulation except loose-fill and aluminum foil, the receipt must show the coverage area, thickness and R-value of the insulation you installed. To figure out the R-value of the insulation, use the data that the manufacturer gives you. The receipt must be dated and signed by the installer. If you put insulation in more than one part of the house, put the data for each part on the receipt. You can do this on one receipt as long as you do not add up the coverage areas or R-values for different parts of the house. Do not multiply the R-value for one inch by the number of inches you installed. For loose-fill, the receipt must show the coverage area, initial installed thickness, minimum settled thickness, R-value and the number of bags used. For aluminum foil, the receipt must show the number and thickness of the air spaces, the direction of heat flow and the R-value.

[70 FR 31276, May 31, 2005]
ASTM C1015 - 06 Standard Practice for Installation of Cellulosic and Mineral Fiber Loose-Fill Thermal Insulation

Significance and Use

This practice recognizes that effectiveness, safety and durability of insulation depend not only on the quality of the insulating materials, but also on their proper installation.

Improper installation of insulation can reduce thermal effectiveness, cause fire risks and other unsafe conditions and promote deterioration of the structure in which it is installed. Specific hazards that can result from improper installation include fires caused by (1) heat build-up in recessed lighting fixtures; (2) deterioration or failure of electrical wiring components; (3) heat buildup resulting from overcurrent protection devices incorrectly matched to wiring; or (4) deterioration in wood structures and paint failure due to moisture accumulation.

This practice provides general procedures that will help ensure the installation of insulation in a safe and effective manner. It must be noted that actual conditions in existing buildings vary greatly, and in some cases substantial additional care and precaution must be taken to ensure effective and safe installation.

1. Scope

1.1 This practice covers procedures for the installation of cellulosic and mineral fiber loose-fill insulation in ceilings, attics and floor and wall cavities of new or existing housing and other framed buildings.

1.2 This practice applies only to the installation of dry loose-fill thermal insulation consisting of cellulosic materials or mineral fiber by pneumatic or pouring application.

1.3 This practice covers the installation process from pre-installation inspection through post-installation procedure. It does not cover the production of the insulation materials.

1.4 This practice is not intended to replace the manufacturer's installation instructions, but shall be used in conjunction with such instructions. This practice is not intended to supersede local, state or federal codes.

1.5 This practice assumes that the installer possesses a good working knowledge of the applicable codes and regulations, safety practices, tools, equipment and methods necessary for the installation of thermal insulation materials. It also assumes that the installer understands the fundamentals of residential construction that affect the installation of insulation.

1.6 The values stated in inch-pound units are to be regarded as the standard. The values given in the parentheses are mathematical conversions to SI units that are provided for informational purposes only.
This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use. For specific precautionary statements, see Section 5.

**Referenced Documents**

**ASTM Standards**
- C168 Terminology Relating to Thermal Insulation
- C739 Specification for Cellulosic Fiber Loose-Fill Thermal Insulation
- C755 Practice for Selection of Water Vapor Retarders for Thermal Insulation
- C764 Specification for Mineral Fiber Loose-Fill Thermal Insulation

**NFPA Standards**

**ICC Document**

**Federal Standard**
ASTM C 1320-05 (09) Standard Practice for Installation of Mineral Fiber Batt and Blanket Insulation Thermal Insulation for Light Frame Construction

Significance and Use

This practice recognizes that effectiveness, safety and durability of insulation depend not only on the quality of the insulating materials, but also on their proper installation.

This practice provides general procedures that will help to ensure installation of insulation in a safe and effective manner. It shall be noted that actual conditions in existing buildings vary greatly and in some cases additional care shall be taken to ensure effective and safe installation.

1. Scope

1.1 This practice covers procedures for the installation of mineral fiber batt and blanket thermal insulation in ceilings, attics, floors and walls of new or existing housing and other light frame construction.

1.2 This practice covers the installation process from pre-installation inspection through post-installation inspection. It does not cover the production of the insulation materials.

1.3 This practice is not intended to replace manufacturers’ installation instructions, but it shall be used in conjunction with such instructions. This practice is not intended to supersede local, state or federal codes.

1.4 This practice assumes that the installer possesses a working knowledge of applicable codes and regulations, safety practices, tools, equipment and methods necessary for the installation of thermal insulation materials. It also assumes that the installer understands the fundamentals of construction that affect the installation of insulation.

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in the parentheses are mathematical conversions to SI units that are provided for informational purposes only.

1.6 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.

IECC Section 303 Materials, Systems and Equipment

303.1.1.1 Blown or sprayed roof/ceiling insulation. The thickness of blown-in or sprayed roof/ceiling insulation (fiberglass or cellulose) shall be written in inches (mm) on markers that are installed – at least one for every 300 square feet (28 m2) throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed
thickness with numbers a minimum of 1 inch (25 mm) in height. Each marker shall face the attic access opening. Spray polyurethane foam thickness and installed R-value shall be listed on certification provided by the insulation installer.

Significance and Use

Air leakage between an air distribution system and unconditioned spaces affects the energy losses from the distribution system, the ventilation rate of the building and the entry rate of air pollutants.

The determination of infiltration energy loads and ventilation rates of residences and small commercial buildings are typically based on the assumption that the principal driving forces for infiltration and ventilation are the wind and indoor or outdoor temperature differences. This can be an inappropriate assumption for buildings that have distribution systems that pass through unconditioned spaces because the existence of relatively modest leakage from that system has a relatively large impact on overall ventilation rates. The air leakage characteristics of these exterior distribution systems are needed to determine their ventilation, energy and pollutant-entry implications.

Air leakage through the exterior air distribution envelope may be treated in the same manner as air leakage in the building envelope as long as the system is not operating (see Test Method E 779). However, when the system blower is on, the pressures across the air distribution system leaks are usually significantly larger than those driving natural infiltration. Depending on the size of the leaks, these pressures can induce much larger flows than natural infiltration. Thus, it is important to be able to isolate these leaks from building envelope leaks. The leakage of air distribution systems must be measured in the field, because it has been shown that workmanship and installation details are more important than design in determining the leakage of these systems.

For codes, standards and other compliance or quality control applications, the precision and repeatability at meeting a specified target (i.e. air flow at reference pressure) is more important than air leakage flows at operating conditions. Some existing codes, standards and voluntary programs require the use of a simpler test method (i.e. Test Method D) that does not separate supply from return leakage, leakage to inside from leakage to outside, or estimate leakage pressures at operating conditions.

5.5 Test Methods A, B and C can be used for energy use calculations, and compliance and quality control applications. Test Method D is intended for use in compliance and quality control only.
1. Scope

1.1 The test methods included in this standard are applicable to the air distribution systems in low-rise residential and commercial buildings.

1.2 The test methods cover four techniques for measuring the air leakage of air distribution systems. The techniques use air flow and pressure measurements to determine the leakage characteristics.

1.3 The test methods for two of the techniques also specify the auxiliary measurements needed to characterize the magnitude of the distribution system air leakage during normal operation.

1.4 A test method for the total re-circulating air flow induced by the system blower is included so that the air distribution system leakage can be normalized as is often required for energy calculations.

1.5 The proper use of the test methods requires knowledge of the principles of air flow and pressure measurements.

1.6 Three of the test methods are intended to produce a measure of the air leakage from the air distribution system to outside. The other test method measures total air leakage, including air leaks to inside conditioned space.

1.7 The values stated in SI units are to be regarded as the standard. The values given in the parentheses are for informational purposes only.

1.8 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use. For specific hazard statements, see Section 7.

Referenced Documents

ASTM Standards
E631 Terminology of Building Constructions
E779 Test Method for Determining Air Leakage Rate by Fan Pressurization
E1258 Test Method for Airflow Calibration of Fan Pressurization Devices

ASME Standard
MFC-3M Measurement of Fluid Flow in Pipes Using Orifice Nozzle and Venturi
ASTM C920 - 10 Standard Specification for Elastomeric Joint Sealants

Abstract

This specification covers the properties of a cured single- or multi-component cold-applied elastomeric joint sealant for sealing, caulking or glazing operations on buildings, plazas and decks for vehicular or pedestrian use, and types of construction other than highway and airfield pavements and bridges. A sealant qualifying under this specification shall be classified by type, grade, class and use as follows: Type S - a single-component sealant, Type M - a multi-component sealant, Grade P - a pourable or self leveling sealant, Grade NS - a nonsag or gunnable sealant, Class 100/50, Class 50, Class 35, Class 25, Class 12.5, Use T, Use NT, Use I, Use M, Use G, Use A and Use O. A single-component sealant shall be a uniform mixture of a consistency suitable for immediate application by hand, pressure caulking gun or hand tool. A multi-component chemically curing sealant shall be furnished in two or more components. A single-component and multi-component sealant, when stored in the original unopened container at temperatures no greater than 27°C (80°F), shall be capable of meeting the requirements for at least six months after the delivery date. Grade P (pourable or self leveling) sealant shall have the required flow characteristics; it shall exhibit a smooth, level surface. Grade NS or gunnable sealant shall have the required flow characteristics when tested in vertical displacement. Type S, Grade P, and Grade NS sealant shall not be less than the given extrusion rate when tested. Type M and Grade P sealant shall be no less than the given extrudable rate 3 h after mixing. Use T (traffic) sealant shall have a hardness reading, after being properly cured, of no less than 25 or no more than 50 when tested. Use NT (nontraffic) sealant shall have a hardness reading, after being properly cured, of no less than 15 or no more than 50 when tested. The sealant shall not lose more than 7% of its original weight or show any cracking or chalking when tested. There shall be no transfer of the sealant to the polyethylene film when tested at 72 h. The sealant shall not cause any visible stain on the top surface of a white cement mortar base when tested. The adhesion and cohesion after cyclic movement shall be tested to meet the requirements prescribed. The adhesion-in-peel test shall be performed to meet the requirements prescribed. The adhesion-in-peel after ultraviolet exposure through glass shall be determined to meet the requirements prescribed. The accelerated weathering effects and sealants exposed to continuous immersion shall be determined to meet the requirements prescribed.

This abstract is a brief summary of the referenced standard. It is for informational purposes only and not an official part of the standard; the full text of the standard itself must be referred to for its use and application. ASTM neither gives any warranty, expressed or implied, nor makes any representation that the contents of this abstract are accurate, complete or timely.

Significance and Use

This specification covers several classifications of sealants, as described in Section 4, for various applications. It should be recognized by the purchaser or design professional that not all sealants meeting this specification are suitable for all applications and all substrates. It is
essential, therefore, that the applicable type, grade, class and use be specified so that the proper classification of sealant is provided for the intended use. Test methods relate to special standard specimen substrates of mortar, glass and aluminum. If tests are required using substrates in addition to or other than the standard, they should be so specified for testing.

1. Scope

1.1 This specification covers the properties of a cured single- or multi-component cold-applied elastomeric joint sealant for sealing, caulking or glazing operations on buildings, plazas and decks for vehicular or pedestrian use, and types of construction other than highway and airfield pavements and bridges.

1.2 A sealant meeting the requirements of this specification shall be designated by the manufacturer to be one or more of the types, classes, grades and uses defined in Section 7.

1.3 The values stated in SI units are to be regarded as the standard. The values given in the parentheses are for informational purposes only.

1.4 This standard is similar, but not identical, to ISO 11600.

Referenced Documents

ASTM Standards
C510 Test Method for Staining and Color Change of Single- or Multi-component Joint Sealants
C639 Test Method for Rheological (Flow) Properties of Elastomeric Sealants
C661 Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer
C679 Test Method for Tack-Free Time of Elastomeric Sealants
C717 Terminology of Building Seals and Sealants
C719 Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)
C793 Test Method for Effects of Laboratory Accelerated Weathering on Elastomeric Joint Sealants
C794 Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
C1183 Test Method for Extrusion Rate of Elastomeric Sealants
C1193 Guide for Use of Joint Sealants
C1246 Test Method for Effects of Heat Aging on Weight Loss, Cracking and Chalking of Elastomeric Sealants After Cure
C1247 Test Method for Durability of Sealants Exposed to Continuous Immersion in Liquids

OSHA 3142-09R, 2003, Lead in Construction
APPLICABILITY TO CONSTRUCTION

OSHA's lead in construction standard applies to all construction work where an employee may be exposed to lead. All work related to construction, alteration or repair, including painting and decorating, is included. Under this standard, construction includes, but is not limited to:

- Demolition or salvage of structures where lead or materials containing lead are present
- Removal or encapsulation of materials containing lead
- New construction, alteration, repair or renovation of structures, substrates or portions of materials containing lead
- Installation of products containing lead
- Lead contamination from emergency cleanup
- Transportation, disposal, storage or containment of lead or materials containing lead where construction activities are performed
- Maintenance operations associated with these construction activities

Employer Responsibilities

WORKER PROTECTIONS

Employers of construction workers are responsible for developing and implementing a worker protection program. At a minimum, the employer's worker protection program for employees exposed to lead above the PEL should include all of the following:

- Hazard determination, including exposure assessment
- Medical surveillance and provisions for medical removal
- Job-specific compliance programs
- Engineering and work practice controls
- Respiratory protection
- Protective clothing and equipment
- Housekeeping
- Hygiene facilities and practices
- Signs
- Employee information and training
- Recordkeeping

Because lead is a cumulative and persistent toxic substance and health effects may result from exposure over prolonged periods of time, employers must use these precautions where feasible to minimize employee exposure to lead. The employer should, as needed, consult a qualified safety and health professional to develop and implement an effective, site-specific worker protection program. These professionals may work independently or may be associated with an insurance carrier, trade organization, or onsite consultation program.
ELEMENTS OF A COMPLIANCE PROGRAM

For each job where employee exposure exceeds the PEL, the employer must establish and implement a written compliance program to reduce employee exposure to the PEL or below. The compliance program must provide for frequent and regular inspections of job sites, materials and equipment by a competent person. Written programs, which must be reviewed and updated at least every six months, must include:

- A description of each activity in which lead is emitted (such as equipment used, material involved, controls in place, crew size, employee job responsibilities, operating procedures and maintenance practices)
- The means to be used to achieve compliance and engineering plans and studies used to determine the engineering controls selected where they are required
- Information on the technology considered to meet the PEL
- Air monitoring data that documents the source of lead emissions
- A detailed schedule for implementing the program, including copies of documentation (such as purchase orders for equipment and construction contracts
- A work practice program
- An administrative control schedule, if applicable
- Arrangements made among contractors on multi-contractor sites to inform employees of potential lead exposure

Hazard Assessment

An employer is required to conduct an initial employee exposure assessment of whether employees are exposed to lead at or above the AL based on:

- Any information, observation or calculation that indicates employee exposure to lead
- Any previous measurements of airborne lead
- Any employee complaints of symptoms attributable to lead exposure

Objective data and historical measurements of lead may be used to satisfy the standard’s initial monitoring requirements.

1. Scope

1.1 This guide describes and compares different methods for assessing the potential for, or existence of, depressurization-induced backdrafting and spillage from vented residential combustion appliances.

1.2 Assessment of depressurization-induced backdrafting and spillage is conducted under either induced depressurization or natural conditions.

1.3 Residential vented combustion appliances addressed in this guide include hot water heaters and furnaces. The guide is also applicable to boilers.

1.4 The methods given in this guide are applicable to Category I (draft-hood- and induced-fan-equipped) furnaces. The guide does not apply to Category III (power-vent-equipped) or Category IV (direct-vent) furnaces.

1.5 The methods in this guide are not intended to identify backdrafting or spillage due to vent blockage or heat-exchanger leakage.

1.6 This guide is not intended to provide a basis for determining compliance with code requirements on appliance and venting installation, but does include a visual assessment of the installation. This assessment may indicate the need for a thorough inspection by a qualified technician.

1.7 Users of the methods in this guide should be familiar with combustion appliance operation and with making house-tightness measurements using a blower door. Some methods described in this guide require familiarity with differential-pressure measurements and use of computer-based data-logging equipment.

This guide does not purport to address all safety concerns, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices, and to determine the applicability of regulatory limitations prior to use. Carbon monoxide (CO) exposure or flame roll-out may occur when performing certain procedures given in this guide. See Section 1, for precautions that must be taken in conducting such procedures.

Referenced Documents

ASTM Standards

D1356 Terminology Relating to Sampling and Analysis of Atmospheres
E631 Terminology of Building Constructions
E779 Test Method for Determining Air Leakage Rate by Fan Pressurization
E1827 Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door

CGSB Standard
51.71 The Spillage Test – Method to Determine the Potential for Pressure-Induced Spillage from Vented, Fuel-Fired and Space Heating Appliances; Water Heaters, and Fireplaces

ANSI Standard
Z21.47 Gas-fired Central Furnace

NFPA Standard
54 National Fuel Gas Code
IV. RESPIRATOR PROTECTION PROGRAM.

A. THE STANDARD. Whenever respirators are required to be worn, a written respirator protection program must be developed and implemented in accordance with OSHA’s respirator standard, 29 CFR 1910.134. (Additional program requirements may be found in the standards that regulate the hazards to which the employee is exposed.) Because workplaces differ substantially, each program must be tailored to the specific conditions of the area. The program must consist of worksite-specific procedures governing the selection, use and care of respirators. The program must be updated as often as necessary to reflect changes in workplace conditions and respirator use.

B. THE WORKSITE-SPECIFIC PROCEDURES. They must contain all of the information needed to maintain an effective respirator program to meet the user’s individual requirements. These procedures are a set of step-by-step instructions written so that a task (i.e. respirator use, fit-testing procedures, cleaning and storage, etc.) can be performed by all personnel in a uniform and consistent way, while supplying the maximum protection for workers who use respirators in the workplace. The employer must anticipate both the routine and non-routine use of respirators, as well as any possible emergency use based on the conditions in the workplace in which they are to be used. Worksite-specific procedures must be written so as to be useful to those who are directly involved in the respirator program: the program administrator, those fitting the respirators and training the workers, respirator maintenance workers and the supervisors responsible for overseeing respirator use on the job.

C. ADMINISTRATION. In addition, the respirator standard requires that the respiratory protection program be administered by one qualified individual to ensure that the integrity of the respiratory protection program is maintained through the continuous oversight of one responsible person. The program administrator must be qualified by appropriate training and/or experience in the proper selection, use and maintenance of respirators, be responsible for implementing the respiratory protection program, and conduct regular evaluations of the program's effectiveness.

Although responsibility for respirator program oversight rests with the program administrator, he or she may delegate responsibilities to other qualified individuals. For instance, a large facility may find it practical and economical to have a staff of personnel involved in the respirator program, each with his or her own area of responsibility. However, each of these individuals must report to the administrator who is responsible for the program. This approach promotes
coordination of all facets of the program. The administrator should have the full support of higher level management; without it, an effective respirator program is difficult to initiate and maintain.

D. ELEMENTS. The respiratory protection program must cover the following basic elements, as applicable:

- Procedures for selecting respirators for use in the workplace
- Medical evaluations of employees required to use respirators
- Fit testing procedures for tight-fitting respirators
- Use of respirators in routine and reasonably foreseeable emergency situations
- Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing and otherwise maintaining respirators
- Procedures to ensure adequate air quality, quantity and flow of breathing air for atmosphere-supplying respirators
- Training of employees in the respiratory hazards to which they are potentially exposed
- Training of employees in the proper use of respirators, including implementing and removing them, any limitations on their use and maintenance procedures
- Procedures for regularly evaluating the effectiveness of the program
SUMMARY OF STANDARDS REFERENCED:

INSULATION
ASTM C 1015 - 06 Standard Practice for Installation of Cellulosic and Mineral Fiber Loose-Fill Thermal Insulation

Significance and Use

This practice recognizes that effectiveness, safety and durability of insulation depend not only on the quality of the insulating materials, but also on its proper installation.

Improper installation of insulation can reduce thermal effectiveness, cause fire risks and other unsafe conditions, and promote deterioration for the structure in which it is installed. Specific hazards that can result from improper installation include fires caused by (1) heat build-up in recessed lighting fixtures; (2) deterioration or failure of electrical wiring components; (3) heat buildup resulting from overcurrent protection devices incorrectly matched to wiring; or (4) deterioration in wood structures and paint failure due to moisture accumulation.

This practice provides general procedures that will help ensure the installation of insulation in a safe and effective manner. It must be noted that actual conditions in existing buildings vary greatly and in some cases substantial additional care and precaution must be taken to ensure effective and safe installation.

1. Scope

1.1 This practice covers procedures for the installation of cellulosic and mineral fiber loose-fill insulation in ceilings, attics and floor and wall cavities of new or existing housing and other framed buildings.

1.2 This practice applies only to the installation of dry loose-fill thermal insulation consisting of cellulosic materials or mineral fiber by pneumatic or pouring application.

1.3 This practice covers the installation process from pre-installation inspection through post-installation procedure. It does not cover the production of the insulation materials.

1.4 This practice is not intended to replace the manufacturer's installation instructions, but shall be used in conjunction with such instructions. This practice is not intended to supersede local, state or federal codes.

1.5 This practice assumes that the installer possesses a good working knowledge of the applicable codes and regulations, safety practices, tools, equipment and methods necessary for the installation of thermal insulation materials. It also assumes that the installer understands the fundamentals of residential construction that affect the installation of insulation.

1.6 The values stated in inch-pound units are to be regarded as the standard. The values given in the parentheses are mathematical conversions to SI units that are provided for informational purposes only.
This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use. For specific precautionary statements, see Section 1.

Referenced Documents

ASTM Standards
C168 Terminology Relating to Thermal Insulation
C739 Specification for Cellulosic Fiber Loose-Fill Thermal Insulation
C755 Practice for Selection of Water Vapor Retarders for Thermal Insulation
C764 Specification for Mineral Fiber Loose-Fill Thermal Insulation

NFPA Standards

ICC Document

Federal Standard
ASTM C 1320-05 (09) Standard Practice for Installation of Mineral Fiber Batt and Blanket Insulation Thermal Insulation for Light Frame Construction

Significance and Use

This practice recognizes that effectiveness, safety and durability of insulation depend not only on the quality of the insulating materials but also on its proper installation.

This practice provides general procedures that will help to ensure installation of insulation in a safe and effective manner. It shall be noted that actual conditions in existing buildings vary greatly and in some cases additional care shall be taken to ensure effective and safe installation.

1. Scope

1.1 This practice covers procedures for the installation of mineral fiber batt and blanket thermal insulation in ceilings, attics, floors and walls of new or existing housing and other light frame construction.

1.2 This practice covers the installation process from pre-installation inspection through post-installation inspection. It does not cover the production of the insulation materials.

1.3 This practice is not intended to replace manufacturers’ installation instructions, but it shall be used in conjunction with such instructions. This practice is not intended to supersede local, state or federal codes.

1.4 This practice assumes that the installer possesses a working knowledge of applicable codes and regulations, safety practices, tools, equipment and methods necessary for the installation of thermal insulation materials. It also assumes that the installer understands the fundamentals of construction that affect the installation of insulation.

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in the parentheses are mathematical conversions to SI units that are provided for informational purposes only.

1.6 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.
IECC Section 303 Materials, Systems and Equipment

303.1.1.1 Blown or sprayed roof/ceiling insulation. The thickness of blown-in or sprayed roof/ceiling insulation (fiberglass or cellulose) shall be written in inches (mm) on markers that are installed – at least one for every 300 square feet (28 m²) throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers a minimum of 1 inch (25 mm) in height. Each marker shall face the attic access opening. Spray polyurethane foam thickness and installed R-value shall be listed on certification provided by the insulation installer.

§ 16CFR460.17 What installers must tell their customers.
If you are an installer, you must give your customers a contract or receipt for the insulation you install. For all insulation except loose-fill and aluminum foil, the receipt must show the coverage area, thickness and R-value of the insulation you installed. To figure out the R-value of the insulation, use the data that the manufacturer gives you. The receipt must be dated and signed by the installer. If you put insulation in more than one part of the house, put the data for each part on the receipt. You can do this on one receipt as long as you do not add up the coverage areas or R-values for different parts of the house. Do not multiply the R-value for one inch by the number of inches you installed. For loose-fill, the receipt must show the coverage area, initial installed thickness, minimum settled thickness, R-value and the number of bags used. For aluminum foil, the receipt must show the number and thickness of the air spaces, the direction of heat flow and the R-value.

[70 FR 31276, May 31, 2005]

Significance and Use

Air infiltration into the conditioned space of a building accounts for a significant portion of the thermal space condition load. Air infiltration can affect occupant comfort by producing drafts, causing indoor air quality problems by carrying outdoor pollutants into occupied building space and, in hot humid climates, depositing moisture in the building envelope resulting in deterioration of building envelope components. In cold climates, exfiltration of conditioned air out of a building can deposit moisture in the building envelope causing deterioration of building envelope components. Differential pressure across the building envelope and the presence of air leakage sites cause air infiltration and exfiltration (1).

In some buildings, restricting air movement between interior zones of a building may be desired to separate dissimilar interior environments or prevent the movement of pollutants. Although not dealt with specifically in this standard, the detection practices presented can also be useful in detecting air leaks between interior zones of the building.

Air leakage sites are often difficult to locate because air flows may be small under the prevailing weather conditions. Wind conditions can aid in air leakage detection by forcing air to enter a building; however, where air is exiting, the building envelope construction may make observations difficult. For these reasons, forced pressurization or depressurization is strongly recommended for those practices that require controlled flow direction.

The techniques for air leakage site detection covered in these practices allow for a wide range of flexibility in the choice of techniques that are best suited for detecting various types of air leakage sites in specific situations.

The infrared scanning technique for air leakage site detection has the advantage of rapid surveying capability. Entire building exterior surfaces or inside wall surfaces can be covered with a single scan or a simple scanning action, provided there are no obscuring thermal effects from construction features or incident solar radiation. The details of a specific air leakage site may then be probed more closely by focusing on the local area. Local leak detection is well addressed with the smoke tracer, anemometer, sound detection, bubble detection and tracer gas techniques. However, these techniques are time consuming for large surfaces. The pressurized or depressurized test chamber and smoke tracer or a depressurized test chamber and leak detection liquid practices can be used in situations where depressurizing or pressurizing the entire envelope is impractical, which is the case during construction. Both of the practices enable the detection of very small leaks. To perform these practices, the air barrier system must be accessible.

Complexity of building air leakage sites may diminish the ability for detection. For example, using the sound detection approach, sound may be absorbed in the tortuous path through the
insulation. Air moving through such building leakage paths may lose some of its temperature differential and thus make thermographic detection difficult. The absence of jet-like air flow at an air leakage site may make detection using the anemometer practice difficult.

Stack effect in multistory commercial buildings can cause gravity dampers to stand open. Computer-controlled dampers should be placed in normal and night modes to aid in determining existing building conditions. Sensitive pressure measurement equipment can be used for evaluating pressure levels between floors and the exterior. Monitoring systems in high-tech buildings can supply qualitative data on pressure differences.

1. Scope

1.1 These practices cover standardized techniques for locating air leakage sites in building envelopes and air barrier systems.

1.2 These practices offer a choice of means for determining the location of air leakage sites with each offering certain advantages for specific applications.

1.3 Some of the practices require knowledge of infrared scanning, building and test chamber pressurization and depressurization, smoke generation techniques, sound generation and detection and tracer gas concentration measurement techniques.

1.4 The practices described are of a qualitative nature in determining the air leakage sites rather than determining quantitative leakage rates.

1.5 The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

1.6 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use. For specific hazard statements, see Section 6.

Referenced Documents

ASTM Standards
E631 Terminology of Building Constructions
E741 Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution
E779 Test Method for Determining Air Leakage Rate by Fan Pressurization

Other Standards
ASTM E84 - 10 Standard Test Method for Surface Burning Characteristics of Building Materials

Significance and Use

This test method is intended to provide only comparative measurements of surface flame spread and smoke density measurements with that of select grade red oak and fiber-cement board surfaces under the specific fire exposure conditions described herein.

This test method exposes a nominal 24 foot (7.32 m) long by 20 inch (508 mm) wide specimen to a controlled air flow and flaming fire exposure adjusted to spread the flame along the entire length of the select grade red oak specimen in five and a half minutes.

This test method does not provide for the following:

Measurement of heat transmission through the tested surface.

The effect of aggravated flame spread behavior of an assembly resulting from the proximity of combustible walls and ceilings.

Classifying or defining a material as noncombustible, by means of a flame spread index by itself.

1. Scope

1.1 This fire-test-response standard for the comparative surface burning behavior of building materials is applicable to exposed surfaces such as walls and ceilings. The test is conducted with the specimen in the ceiling position with the surface to be evaluated exposed face down to the ignition source. The material, product or assembly shall be capable of being mounted in the test position during the test. Thus, the specimen shall either be self-supporting by its own structural quality, held in place by added supports along the test surface or secured from the back side.

1.2 The purpose of this test method is to determine the relative burning behavior of the material by observing the flame spread along the specimen. Flame spread and smoke developed index are reported. However, there is not necessarily a relationship between these two measurements.

1.3 The use of supporting materials on the underside of the test specimen has the ability to lower the flame spread index from those which might be obtained if the specimen could be tested without such support. These test results do not necessarily relate to indices obtained by testing materials without such support.

1.4 Testing of materials that melt, drip or delaminate to such a degree that the continuity of the flame front is destroyed, results in low flame spread indices that do not relate directly to indices obtained by testing materials that remain in place.
1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in the parentheses are mathematical conversions to SI units that are provided for informational purposes only.

1.6 The text of this standard references notes and footnotes that provide explanatory information. These notes and footnotes, excluding those in tables and figures, shall not be considered as requirements of the standard.

1.7 This standard is used to measure and describe the response of materials, products or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire-hazard or fire-risk assessment of the materials, products or assemblies under actual fire conditions.

1.8 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.

**Referenced Documents**

**ASTM Standards**
- A390 Specification for Zinc-Coated (Galvanized) Steel Poultry Fence Fabric (Hexagonal and Straight Line)
- C1186 Specification for Flat Fiber-Cement Sheets
- D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials
- D4444 Test Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters
- E69 Test Method for Combustible Properties of Treated Wood by the Fire-Tube Apparatus
- E136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C
- E176 Terminology of Fire Standards
- E2231 Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics
- E2404 Practice for Specimen Preparation and Mounting of Textile, Paper or Polymeric (Including Vinyl) Wall or Ceiling Coverings to Assess Surface Burning Characteristics
- E2573 Practice for Specimen Preparation and Mounting of Site-Fabricated Stretch Systems to Assess Surface Burning Characteristics
- E2579 Practice for Specimen Preparation and Mounting of Wood Products to Assess Surface Burning Characteristics
- E2599 Practice for Specimen Preparation and Mounting of Reflective Insulation Materials and Radiant Barrier Materials for Building Applications to Assess Surface Burning Characteristics

**UL Standards**

**NFPA Standards**
NFPA262 Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces (2007)
ASTM C755 - 03 Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation

1. Scope

1.1 This practice outlines factors to be considered, describes design principles and procedures for water vapor retarder selection and defines water vapor transmission values appropriate for established criteria. It is intended for the guidance of design engineers in preparing vapor retarder application specifications for control of water vapor flow through thermal insulation. It covers commercial and residential building construction and industrial applications in the service temperature range from -40 to +150°F (-40 to +66°C). Emphasis is placed on the control of moisture penetration by choice of the most suitable components of the system.

1.2 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.

Referenced Documents

ASTM Standards

C168 Terminology Relating to Thermal Insulation
C647 Guide to Properties and Test Methods of Mastics and Coating Finishes for Thermal Insulation
C921 Specifications for Jackets for Thermal Insulation
C1136 Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation

Significance and Use

Vapor inhalation is the primary hazard encountered during the use of chlorinated solvents. The greatest potential for overexposure to these solvent vapors occurs where the employee is exposed to the high concentrations of vapor that may be found in confined areas. The seriousness of this hazard is often underestimated by those performing this type of work.

This practice is designed for use by employers in developing their own specific standards for vessel or confined area entry.

Many of these areas are considered as permit-required confined spaces as defined by OSHA (29 CFR 1910.146). The determination of the applicability of these requirements is the responsibility of the user.

This practice represents the minimum requirements for entry into any confined area containing halogenated solvents.

This practice does not address all of the requirements contained in the OSHA confined spaces standard. Development and implementation of training programs, recordkeeping and other additional requirements of the OSHA standard are the responsibility of the user.

1. Scope

1.1 This practice covers recognized procedures necessary to protect the health and safety of workers required to enter confined spaces. These procedures are particularly applicable to entry into confined areas associated with the use of halogenated organic solvents.

1.2 Confined areas addressed in this practice include, but are not limited to: vapor degreasers, cold cleaning tanks, storage vessels, tank cars and trucks, van trailers, ships or barges, pits or sumps and unventilated rooms.

1.3 This practice does not necessarily address entry into all confined spaces, nor does it address the decision strategy involved in requiring such entry.

1.4 Although this practice describes specific safety steps to be taken for entry into confined spaces, it is not intended to preclude the use of any additional measures that may be deemed necessary for a particular situation.

1.5 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.

OSHA 3142-09R, 2003, Lead in Construction
APPLICABILITY TO CONSTRUCTION

OSHA's lead in construction standard applies to all construction work where an employee may be exposed to lead. All work related to construction, alteration or repair, including painting and decorating, is included. Under this standard, construction includes, but is not limited to:

1. Demolition or salvage of structures where lead or materials containing lead are present
2. Removal or encapsulation of materials containing lead
3. New construction, alteration, repair or renovation of structures, substrates or portions of materials containing lead
4. Installation of products containing lead
5. Lead contamination from emergency cleanup
6. Transportation, disposal, storage or containment of lead or materials containing lead where construction activities are performed
7. Maintenance operations associated with these construction activities

Employer Responsibilities

WORKER PROTECTIONS

Employers of construction workers are responsible for developing and implementing a worker protection program. At a minimum, the employer's worker protection program for employees exposed to lead above the PEL should include:

1. Hazard determination, including exposure assessment
2. Medical surveillance and provisions for medical removal
3. Job-specific compliance programs
4. Engineering and work practice controls
5. Respiratory protection
6. Protective clothing and equipment
7. Housekeeping
8. Hygiene facilities and practices
9. Signs
10. Employee information and training
11. Recordkeeping

Because lead is a cumulative and persistent toxic substance and health effects may result from exposure over prolonged periods of time, employers must use these precautions where feasible to minimize employee exposure to lead. The employer should, as needed, consult a qualified safety and health professional to develop and implement an effective, site-specific worker
protection program. These professionals may work independently or may be associated with an insurance carrier, trade organization or onsite consultation program.

ELEMENTS OF A COMPLIANCE PROGRAM

For each job where employee exposure exceeds the PEL, the employer must establish and implement a written compliance program to reduce employee exposure to the PEL or below. The compliance program must provide for frequent and regular inspections of job sites, materials and equipment by a competent person. Written programs, which must be reviewed and updated at least every six months, must include:

1. A description of each activity in which lead is emitted (i.e. equipment used, material involved, controls in place, crew size, employee job responsibilities, operating procedures and maintenance practices)
2. The means to be used to achieve compliance and engineering plans and studies used to determine the engineering controls selected where they are required
3. Information on the technology considered to meet the PEL
4. Air monitoring data that documents the source of lead emissions
5. A detailed schedule for implementing the program, including copies of documentation (i.e. purchase orders for equipment and construction contracts)
6. A work practice program
7. An administrative control schedule, if applicable
8. Arrangements made among contractors on multi-contractor sites to inform employees of potential lead exposure

Hazard Assessment

An employer is required to conduct an initial employee exposure assessment of whether employees are exposed to lead at or above the AL based on:

1. Any information, observation or calculation that indicates employee exposure to lead
2. Any previous measurements of airborne lead
3. Any employee complaints of symptoms attributable to lead exposure

Objective data and historical measurements of lead may be used to satisfy the standard's initial monitoring requirements.
SUMMARY OF STANDARDS REFERENCED:
VENTILATION
Standard 62.2-2010 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings (ANSI/ASHRAE Approved)

This standard defines the roles and minimum requirements for mechanical and natural ventilation systems and the building envelope intended to provide acceptable indoor air quality in low-rise residential buildings. It is ASHRAE's IAQ standard for residential buildings.

The standard applies to spaces intended for human occupancy within single-family houses and multi-family structures of three stories or fewer above grade, including manufactured and modular houses. This standard does not apply to transient housing such as hotels, motels, nursing homes, dormitories and jails.

Since 2003, extensive experience has been gained in the application of this standard due to its adoption by various building codes and use in numerous building programs. As such, many clarifications and improvements have been identified and incorporated through the approved addenda. One significant addition is the new normative appendix addressing the application of the standard to existing buildings.


1. Scope

1.1 This guide describes and compares different methods for assessing the potential for, or existence of, depressurization-induced backdrafting and spillage from vented residential combustion appliances.

1.2 Assessment of depressurization-induced backdrafting and spillage is conducted under either induced depressurization or natural conditions.

1.3 Residential vented combustion appliances addressed in this guide include hot water heaters and furnaces. The guide is also applicable to boilers.

1.4 The methods given in this guide are applicable to Category I (draft-hood- and induced-fan-equipped) furnaces. The guide does not apply to Category III (power-vent-equipped) or Category IV (direct-vent) furnaces.

1.5 The methods in this guide are not intended to identify backdrafting or spillage due to vent blockage or heat-exchanger leakage.

1.6 This guide is not intended to provide a basis for determining compliance with code requirements on appliance and venting installation, but does include a visual assessment of the installation. This assessment may indicate the need for a thorough inspection by a qualified technician.

1.7 Users of the methods in this guide should be familiar with combustion appliance operation and with making house tightness measurements using a blower door. Some methods described in this guide require familiarity with differential-pressure measurements and use of computer-based data-logging equipment.

This guide does not purport to address all safety concerns, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices, and to determine the applicability of regulatory limitations prior to use. Carbon monoxide (CO) exposure or flame roll-out may occur when performing certain procedures given in this guide. See Section 1, for precautions that must be taken in conducting such procedures.

Referenced Documents

ASTM Standards
D1356 Terminology Relating to Sampling and Analysis of Atmospheres
E631 Terminology of Building Constructions
E779 Test Method for Determining Air Leakage Rate by Fan Pressurization
E1827 Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door

CGSB Standard

51.71 The Spillage Test – Method to Determine the Potential for Pressure-Induced Spillage from Vented, Fuel-Fired; Space Heating Appliances; Water Heaters, and Fireplaces

ANSI Standard

Z21.47 Gas-fired Central Furnace

NFPA Standard

54 National Fuel Gas Code
ASTM C 1320-05 (09) Standard Practice for Installation of Mineral Fiber Batt and Blanket Insulation Thermal Insulation for Light Frame Construction

Significance and Use

This practice recognizes that effectiveness, safety and durability of insulation depend not only on the quality of the insulating materials, but also on proper installation.

This practice provides general procedures that will help to ensure installation of insulation in a safe and effective manner. It shall be noted that actual conditions in existing buildings vary greatly and in some cases additional care shall be taken to ensure effective and safe installation.

1. Scope

1.1 This practice covers procedures for the installation of mineral fiber batt and blanket thermal insulation in ceilings, attics, floors and walls of new or existing housing and other light frame construction.

1.2 This practice covers the installation process from pre-installation inspection through post-installation inspection. It does not cover the production of the insulation materials.

1.3 This practice is not intended to replace manufacturers’ installation instructions, but it shall be used in conjunction with such instructions. This practice is not intended to supersede local, state or federal codes.

1.4 This practice assumes that the installer possesses a working knowledge of applicable codes and regulations, safety practices, tools, equipment and methods necessary for the installation of thermal insulation materials. It also assumes that the installer understands the fundamentals of construction that affect the installation of insulation.

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in the parentheses are mathematical conversions to SI units that are provided for informational purposes only.

1.6 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.
ASTM C920 - 10 Standard Specification for Elastomeric Joint Sealants

Abstract

This specification covers the properties of a cured single- or multi-component cold-applied elastomeric joint sealant for sealing, caulking or glazing operations on buildings, plazas and decks for vehicular or pedestrian use, and types of construction other than highway and airfield pavements and bridges. A sealant qualifying under this specification shall be classified by type, grade, class and use as follows: Type S - a single-component sealant, Type M - a multi-component sealant, Grade P - a pourable or self leveling sealant, Grade NS - a nonsag or gunnable sealant, Class 100/50, Class 50, Class 35, Class 25, Class 12.5, Use T, Use NT, Use I, Use M, Use G, Use A and Use O. A single-component sealant shall be a uniform mixture of a consistency suitable for immediate application by hand, pressure caulking gun or hand tool. A multi-component chemically curing sealant shall be furnished in two or more components. A single-component and multi-component sealant, when stored in the original unopened container at temperatures no greater than 27°C (80°F), shall be capable of meeting the requirements for at least six months after the delivery date. Grade P (pourable or self leveling) sealant shall have the required flow characteristics; it shall exhibit a smooth, level surface. Grade NS or gunnable sealant shall have the required flow characteristics when tested in vertical displacement. Type S, Grade P and Grade NS sealant shall not be less than the given extrusion rate when tested. Type M and Grade P sealant, when tested, shall be not less than the given extrudable rate 3 h after mixing. Use T (traffic) sealant shall have a hardness reading, after being properly cured, of no less than 25 or no more than 50 when tested. Use NT (nontraffic) sealant shall have a hardness reading, after being properly cured, of no less than 15 or no more than 50 when tested. The sealant shall not lose more than 7% of its original weight or show any cracking or chalking when tested. There shall be no transfer of the sealant to the polyethylene film when tested at 72 h. The sealant shall not cause any visible stain on the top surface of a white cement mortar base when tested. The adhesion and cohesion after cyclic movement shall be tested to meet the requirements prescribed. The adhesion-in-peel test shall be performed to meet the requirements prescribed. The adhesion-in-peel after ultraviolet exposure through glass shall be determined to meet the requirements prescribed. The accelerated weathering effects and sealants exposed to continuous immersion shall be determined to meet the requirements prescribed.

This abstract is a brief summary of the referenced standard. It is for informational purposes only and not an official part of the standard; the full text of the standard itself must be referred to for its use and application. ASTM neither gives any warranty, expressed or implied, nor makes any representation that the contents of this abstract are accurate, complete or timely.

Significance and Use

This specification covers several classifications of sealants as described in Section 4 for various applications. It should be recognized by the purchaser or design professional that not all sealants meeting this specification are suitable for all applications and all substrates. It is
essential, therefore, that the applicable type, grade, class and use be specified so that the proper classification of sealant is provided for the intended use. Test methods relate to special standard specimen substrates of mortar, glass and aluminum. If tests are required using substrates in addition to or other than the standard, they should be so specified for testing.

1. Scope

1.1 This specification covers the properties of a cured single or multi-component cold-applied elastomeric joint sealant for sealing, caulking or glazing operations on buildings, plazas and decks for vehicular or pedestrian use, and types of construction other than highway and airfield pavements and bridges.

1.2 A sealant meeting the requirements of this specification shall be designated by the manufacturer to be one or more of the types, classes, grades and uses defined in Section 7.

1.3 The values stated in SI units are to be regarded as the standard. The values given in the parentheses are for informational purposes only.

1.4 This standard is similar, but not identical, to ISO 11600.

Referenced Documents

ASTM Standards
C510 Test Method for Staining and Color Change of Single- or Multi-component Joint Sealants
C639 Test Method for Rheological (Flow) Properties of Elastomeric Sealants
C661 Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer
C679 Test Method for Tack-Free Time of Elastomeric Sealants
C717 Terminology of Building Seals and Sealants
C719 Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)
C793 Test Method for Effects of Laboratory Accelerated Weathering on Elastomeric Joint Sealants
C794 Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
C1183 Test Method for Extrusion Rate of Elastomeric Sealants
C1193 Guide for Use of Joint Sealants
C1246 Test Method for Effects of Heat Aging on Weight Loss, Cracking and Chalking of Elastomeric Sealants After Cure
C1247 Test Method for Durability of Sealants Exposed to Continuous Immersion in Liquids

OSHA 3142-09R, 2003, Lead in Construction
OSHA's lead in construction standard applies to all construction work where an employee may be exposed to lead. All work related to construction, alteration or repair, including painting and decorating, is included. Under this standard, construction includes, but is not limited to:

- Demolition or salvage of structures where lead or materials containing lead are present
- Removal or encapsulation of materials containing lead
- New construction, alteration, repair or renovation of structures, substrates or portions of materials containing lead
- Installation of products containing lead
- Lead contamination from emergency cleanup
- Transportation, disposal, storage or containment of lead or materials containing lead where construction activities are performed
- Maintenance operations associated with these construction activities

Employer Responsibilities

Worker Protections

Employers of construction workers are responsible for developing and implementing a worker protection program. At minimum, the employer's worker protection program for employees exposed to lead above the PEL should include:

- Hazard determination, including exposure assessment
- Medical surveillance and provisions for medical removal
- Job-specific compliance programs
- Engineering and work practice controls
- Respiratory protection
- Protective clothing and equipment
- Housekeeping
- Hygiene facilities and practices
- Signs
- Employee information and training
- Recordkeeping

Because lead is a cumulative and persistent toxic substance and health effects may result from exposure over prolonged periods, employers must use these precautions when feasible to minimize employee exposure to lead. The employer should, as needed, consult a qualified safety and health professional to develop and implement an effective, site-specific worker protection program. These professionals may work independently or may be associated with an insurance carrier, trade organization or onsite consultation program.
ELEMENTS OF A COMPLIANCE PROGRAM

For each job where employee exposure exceeds the PEL, the employer must establish and implement a written compliance program to reduce employee exposure to the PEL or below. The compliance program must provide for frequent and regular inspections of job sites, materials and equipment by a competent person. Written programs, which must be reviewed and updated at least every six months, must include:

- A description of each activity in which lead is emitted (i.e. as equipment used, material involved, controls in place, crew size, employee job responsibilities, operating procedures and maintenance practices)
- The means to be used to achieve compliance and engineering plans and studies used to determine the engineering controls selected where they are required
- Information on the technology considered to meet the PEL
- Air monitoring data that documents the source of lead emissions
- A detailed schedule for implementing the program, including copies of documentation (i.e. purchase orders for equipment and construction contracts)
- A work practice program
- An administrative control schedule, if applicable
- Arrangements made among contractors on multi-contractor sites to inform employees of potential lead exposure

Hazard Assessment

An employer is required to conduct an initial employee exposure assessment of whether employees are exposed to lead at or above the AL based on:

- Any information, observation or calculation that indicates employee exposure to lead
- Any previous measurements of airborne lead
- Any employee complaints of symptoms attributable to lead exposure

Objective data and historical measurements of lead may be used to satisfy the standard's initial monitoring requirements.


- Prohibit work on new and existing energized (hot) electrical circuits until all power is shut off and a positive Lockout/Tagout System is in place
- Don't use frayed or worn electrical cords or cables
- Use only three-wire type extension cords designed for hard or junior hard service (look for any of the following letters imprinted on the casing: S, ST, SO, STO, SJ, SJT, SJO, SJTO)
- Maintain all electrical tools and equipment in safe condition and check regularly for defects
- Remove broken or damaged tools and equipment from the jobsite
- Protect all temporary power (including extension cords) with ground fault circuit interrupters (GFCIs). Plug into a GFCI-protected temporary power pole, a GFCI protected generator or use a GFCI extension cord to protect against shocks (figure 22).
- Don't bypass any protective system or device designed to protect employees from contact with electrical currents.
- Locate and identify overhead electrical power lines. Make sure that ladders, scaffolds, equipment or materials never come within 10 feet of electrical power lines.
SUMMARY OF STANDARDS REFERENCED:
HEATING AND COOLING
(ANSI/ASHRAE Approved)

1. Scope

2.1 This standard provides minimum energy efficiency requirements for the design and  
construction of:

   a) New residential dwelling units and their systems and
   b) Where explicitly specified,
       1. New portions of residential dwelling units and
       2. Their systems and new systems, and equipment in existing dwelling units

For the purposes of this standard, "residential dwelling units" include single-family houses,  
multi-family structures (of three stories or fewer above grade) and modular houses. This  
standard does not include "transient" housing such as hotels, motels, nursing homes, jails and  
barracks, or manufactured housing.

2.2 This standard applies to the building envelope, heating equipment and systems, air-  
conditioning equipment and systems, domestic water-heating equipment and systems and  
provisions for overall building design alternatives and trade-offs.

2.3 This standard does not apply to:

   • Specific procedures for the operation, maintenance and use of residential buildings
   • Portable products such as appliances and heaters
   • Residential electric service or lighting requirements

2.4 This standard shall not be used to abridge any safety, health, or environmental  
requirements.

SMACNA HVAC Duct Construction Standard Third Addition 2005

The third edition of the HVAC Duct Construction Standards – Metal and Flexible is intended primarily for commercial and institutional duct construction. This American National Standard (ANSI/SMACNA 006-2006) contains tables and details for constructing ductwork for ½" to 10" wg positive and negative pressures. This edition improves upon the second edition with expanded pressure class tables, separate tables for TDC/TDF construction and expanded tables for round duct construction including 6" wg positive and negative pressure and sizes up to 96". New in this edition is an engineering and design chapter to provide additional information to design professionals, double-wall construction details, new casing construction details and additional accessory items. The standard is applicable for construction using uncoated steel, galvanized and stainless steels, and a limited range of aluminum ducts. This standard has been adopted in the ICC International Mechanical Code (includes soft metrics, 390 pages, 3rd Edition, 2005).
NFPA 31: Standard for the Installation of Oil-Burning Equipment

1.1 Scope

1.1.1 This standard shall apply to the installation of stationary oil-burning equipment and appliances, including but not limited to industrial-, commercial-, and residential-type steam, hot water or warm air heating plants; domestic-type range burners and space heaters; and portable oil-burning equipment.

1.1.2 This standard shall apply to all accessory equipment and control systems, whether electric, thermostatic or mechanical, and all electrical wiring connected to oil-fired equipment.

1.1.3 This standard shall apply to the installation of oil storage and supply systems connected to oil-fired equipment and appliances.

1.1.4 This standard shall apply to multi-fueled appliances in which fuel oil is one of the optional fuels.

1.1.5* This standard shall not apply to internal combustion engines, oil lamps or portable devices not specifically covered in this standard. (See Chapter 11 for portable devices that are covered in this standard).
OSH Act of 1970

SEC. 5. Duties

(a) Each employer:

   (1) Shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm.

   (2) Shall comply with occupational safety and health standards promulgated under this Act.

(b) Each employee shall comply with occupational safety and health standards and all rules, regulations and orders issued pursuant to this Act which are applicable to his own actions and conduct.
40 CFR 82.154 Title 40: Protection of Environment Part 82—Protection of Stratospheric Ozone

82.154 Prohibitions.

(a)(1) Effective June 13, 2005, no person maintaining, servicing, repairing or disposing of appliances may knowingly vent or otherwise release into the environment any refrigerant or substitute from such appliances, with the exception of the following substitutes in the following end-uses:

(i) Ammonia in commercial or industrial process refrigeration or in absorption units

(ii) Hydrocarbons in industrial process refrigeration (processing of hydrocarbons)

(iii) Chlorine in industrial process refrigeration (processing of chlorine and chlorine compounds)

(iv) Carbon dioxide in any application

(v) Nitrogen in any application

(vi) Water in any application

(2) The knowing release of a refrigerant or non-exempt substitute subsequent to its recovery from an appliance shall be considered a violation of this prohibition. De minimis releases associated with good faith attempts to recycle or recover refrigerants or non-exempt substitutes are not subject to this prohibition. Refrigerant releases shall be considered de minimis only if they occur when:

(i) The required practices set forth in §82.156 are observed, recovery or recycling machines that meet the requirements set forth in §82.158 are used, and the technician certification provisions set forth in §82.161 are observed; or

(ii) The requirements set forth in subpart B of this part are observed.
NFPA 90B: Standard for the Installation of Warm Air Heating and Air Conditioning Systems

This standard provides the most up-to-date guidelines to keep fire and smoke from spreading through indoor environmental systems in small buildings and 1- and 2-family dwellings. Rules cover construction, installation, operation and maintenance of systems for warm air heating and air conditioning, including filters, ducts and related equipment to protect life and property from fire, smoke and gases resulting from fire or conditions having manifestations similar to fire.

Contents

Chapter 1: Administration
Chapter 2: Referenced Publications
Chapter 3: Definitions
Chapter 4: System Components
Chapter 5: Fire Integrity of Building Construction
Chapter 6: Equipment, Wiring and Controls
Annex A: Explanatory Material
Annex B: Informational References
Index

Subpart B—Standards for Small Quantity Handlers of Universal Waste

273.13 Waste management
(c) Mercury-containing equipment. A small quantity handler of universal waste must manage universal waste mercury-containing equipment in a way that prevents releases of any universal waste or component of a universal waste to the environment:

(1) A small quantity handler of universal waste must place in a container any universal waste mercury-containing equipment with non-contained elemental mercury or that shows evidence of leakage, spillage or damage that could cause leakage under reasonably foreseeable conditions. The container must be closed, structurally sound, compatible with the contents of the device, must lack evidence of leakage, spillage or damage that could cause leakage under reasonably foreseeable conditions, and must be reasonably designed to prevent the escape of mercury into the environment by volatilization or any other means.

(2) A small quantity handler of universal waste may remove mercury-containing ampules from universal waste mercury-containing equipment provided the handler:

(i) Removes and manages the ampules in a manner designed to prevent breakage of the ampules

(ii) Removes the ampules only over or in a containment device (i.e. tray or pan sufficient to collect and contain any mercury released from an ampule in case of breakage)

(iii) Ensures that a mercury clean-up system is readily available to immediately transfer any mercury resulting from spills or leaks from broken ampules from the containment device to a container that meets the requirements of 40 CFR 262.34

(iv) Immediately transfers any mercury resulting from spills or leaks from broken ampules from the containment device to a container that meets the requirements of 40 CFR 262.34

(v) Ensures that the area in which ampules are removed is well ventilated and monitored to ensure compliance with applicable OSHA exposure levels for mercury

(vi) Ensures that employees removing ampules are thoroughly familiar with proper mercury handling and emergency procedures, including transfer of mercury from containment devices to appropriate containers

(vii) Stores removed ampules in closed, non-leaking containers that are in good condition
(viii) Packs removed ampules in the container with packing materials adequate to prevent breakage during storage, handling and transportation
OSHA 3142-09R, 2003, Lead in Construction

APPLICABILITY TO CONSTRUCTION

OSHA’s lead in construction standard applies to all construction work where an employee may be exposed to lead. All work related to construction, alteration or repair, including painting and decorating, is included. Under this standard, construction includes, but is not limited to:

- Demolition or salvage of structures where lead or materials containing lead are present
- Removal or encapsulation of materials containing lead
- New construction, alteration, repair or renovation of structures, substrates or portions of materials containing lead
- Installation of products containing lead
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- Maintenance operations associated with these construction activities

Employer Responsibilities

WORKER PROTECTIONS

Employers of construction workers are responsible for developing and implementing a worker protection program. At minimum, the employer’s worker protection program for employees exposed to lead above the PEL should include:

- Hazard determination, including exposure assessment
- Medical surveillance and provisions for medical removal
- Job-specific compliance programs
- Engineering and work practice controls
- Respiratory protection
- Protective clothing and equipment
- Housekeeping
- Hygiene facilities and practices
- Signs
- Employee information and training
- Recordkeeping

Because lead is a cumulative and persistent toxic substance and health effects may result from exposure over prolonged periods, employers must use these precautions when feasible to minimize employee exposure to lead. The employer should, as needed, consult a qualified safety and health professional to develop and implement an effective, site-specific worker
protection program. These professionals may work independently or may be associated with an insurance carrier, trade organization or onsite consultation program.

**ELEMENTS OF A COMPLIANCE PROGRAM**

For each job where employee exposure exceeds the PEL, the employer must establish and implement a written compliance program to reduce employee exposure to the PEL or below. The compliance program must provide for frequent and regular inspections of job sites, materials and equipment by a competent person. Written programs, which must be reviewed and updated at least every six months, must include:

- A description of each activity in which lead is emitted (i.e. equipment used, material involved, controls in place, crew size, employee job responsibilities, operating procedures and maintenance practices)
- The means to be used to achieve compliance and engineering plans and studies used to determine the engineering controls selected where they are required
- Information on the technology considered to meet the PEL
- Air monitoring data that documents the source of lead emissions
- A detailed schedule for implementing the program, including copies of documentation (i.e. purchase orders for equipment and construction contracts)
- A work practice program
- An administrative control schedule, if applicable
- Arrangements made among contractors on multi-contractor sites to inform employees of potential lead exposure

**Hazard Assessment**

An employer is required to conduct an initial employee exposure assessment of whether employees are exposed to lead at or above the AL based on:

- Any information, observation or calculation that indicates employee exposure to lead
- Any previous measurements of airborne lead
- Any employee complaints of symptoms attributable to lead exposure

Objective data and historical measurements of lead may be used to satisfy the standard's initial monitoring requirements.
ASTM C1193 - 09 Standard Guide for Use of Joint Sealants

Significance and Use

This guide provides information and guidelines for consideration by the designer or applicator of a joint seal. It explains the properties and functions of various materials, such as sealant, sealant backing and primer, among others; and, procedures such as substrate cleaning and priming, and installation of the components of a sealed joint. It presents guidelines for the use and application of the various materials, design of a sealant joint for a specific application, and environmental conditions and effects that are known to detrimentally affect a sealant joint. The information and guidelines are also useful for those who supply accessories to the sealant industry and for those who install sealants and accessory materials associated with sealant use.

In addition to the design and installation data in this guide, consult the sealant manufacturer about applications for products and proper use and installation. Considering the range of properties of commercially available sealants, the variety of joint designs possible and the many conditions of use, the information contained herein is general in nature.

To assist the user of the guide in locating specific information, a detailed listing of guide numbered sections and their descriptors are included in Appendix X2.

1. Scope

1.1 This guide describes the use of a cold liquid-applied sealant for joint sealing applications, including joints on buildings and related adjacent areas such as plazas, decks and pavements for vehicular or pedestrian use, and types of construction other than highways and airfield pavements and bridges. Information in this guide is primarily applicable to a single- and multi-component, cold liquid-applied joint sealant and secondarily to a procured sealant when used with a properly prepared joint opening and substrate surfaces.

1.2 An elastomeric or non-elastomeric sealant described in this guide should meet the requirements of Specification C 834, C 920 or C 1311.

1.3 This guide does not provide information or guidelines for the use of a sealant in a structural sealant glazing application. Guide C 1401 should be consulted for this information. Additionally, it also does not provide information or guidelines for the use of a sealant in an insulating glass unit edge seal used in a structural sealant glazing application. Guide C 1249 should be consulted for this information.

1.4 Practice C 919 should be consulted for information and guidelines for the use of a sealant in an application where an acoustic joint seal is required.

1.5 This guide also does not provide information relative to the numerous types of sealant that are available, nor specific generic sealant properties such as hardness, tack-free time or curing
process, among others. Guide C 1299 should be consulted for information on generally accepted comparative values for the characteristics and properties of the more common generic types of liquid-applied sealant.

1.6 The values stated in SI units are to be regarded as the standard. The values given in the parenthesis are provided for informational purposes only.

1.7 The committee with jurisdiction for this standard is not aware of any comparable standards published by other organizations.

1.8 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.

Referenced Documents

ASTM Standards
C510 Test Method for Staining and Color Change of Single- or Multicomponent Joint Sealants
C717 Terminology of Building Seals and Sealants
C719 Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)
C792 Test Method for Effects of Heat Aging on Weight Loss, Cracking and Chalking of Elastomeric Sealants
C794 Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
C834 Specification for Latex Sealants
C919 Practice for Use of Sealants in Acoustical Applications
C920 Specification for Elastomeric Joint Sealants
C1083 Test Method for Water Absorption of Cellular Elastomeric Gaskets and Sealing Materials
C1087 Test Method for Determining Compatibility of Liquid-Applied Sealants with Accessories Used in Structural Glazing Systems
C1135 Test Method for Determining Tensile Adhesion Properties of Structural Sealants
C1247 Test Method for Durability of Sealants Exposed to Continuous Immersion in Liquids
C1248 Test Method for Staining of Porous Substrate by Joint Sealants
C1249 Guide for Secondary Seal for Sealed Insulating Glass Units for Structural Sealant Glazing Applications
C1253 Test Method for Determining the Outgassing Potential of Sealant Backing
C1299 Guide for Use in Selection of Liquid-Applied Sealants
C1311 Specification for Solvent Release Sealants
C1330 Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants
C1401 Guide for Structural Sealant Glazing
C1442 Practice for Conducting Tests on Sealants Using Artificial Weathering Apparatus
C1472 Guide for Calculating Movement and Other Effects When Establishing Sealant Joint Width
D2203 Test Method for Staining from Sealants
NFPA 70A: National Electrical Code® Requirements for One-and Two-Family Dwellings

Scope

(A) This Code covers the installation of electrical conductors, equipment and raceways; signaling and communications conductors, equipment and raceways; and optical fiber cables and raceways for the following:

(1) Public and private premises, including buildings, structures, mobile homes, recreational vehicles and floating buildings
(2) Yards, lots, parking lots, carnivals and industrial substations
(3) Installations of conductors and equipment that connect to the supply of electricity
(4) Installations used by the electric utility, such as office buildings, warehouses, garages, machine shops and recreational buildings, that are not an integral part of a generating plant, substation or control center
Standard 62.2-2010 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings (ANSI/ASHRAE Approved)

This standard defines the roles and minimum requirements for mechanical and natural ventilation systems and the building envelope intended to provide acceptable indoor air quality in low-rise residential buildings. It is ASHRAE’s IAQ standard for residential buildings.

It applies to spaces intended for human occupancy within single-family houses and multi-family structures of three stories or fewer above grade, including manufactured and modular houses. This standard does not apply to transient housing such as hotels, motels, nursing homes, dormitories and jails.

Since 2003, extensive experience has been gained in the application of this standard due to its adoption by various building codes and use in numerous building programs. As such, many clarifications and improvements have been identified and incorporated through the approved addenda. One significant addition is the new normative appendix addressing the application of the standard to existing buildings.


1. Scope

1.1 This guide describes and compares different methods for assessing the potential for, or existence of, depressurization-induced backdrafting and spillage from vented residential combustion appliances.

1.2 Assessment of depressurization-induced backdrafting and spillage is conducted under either induced depressurization or natural conditions.

1.3 Residential vented combustion appliances addressed in this guide include hot water heaters and furnaces. The guide also is applicable to boilers.

1.4 The methods given in this guide are applicable to Category I (draft-hood- and induced-fan-equipped) furnaces. The guide does not apply to Category III (power-vent-equipped) or Category IV (direct-vent) furnaces.

1.5 The methods in this guide are not intended to identify backdrafting or spillage due to vent blockage or heat-exchanger leakage.

1.6 This guide is not intended to provide a basis for determining compliance with code requirements on appliance and venting installation, but does include a visual assessment of the installation. This assessment may indicate the need for a thorough inspection by a qualified technician.

1.7 Users of the methods in this guide should be familiar with combustion appliance operation and with making house tightness measurements using a blower door. Some methods described in this guide require familiarity with differential-pressure measurements and use of computer-based data-logging equipment.

This guide does not purport to address all safety concerns, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices, and to determine the applicability of regulatory limitations prior to use. Carbon monoxide (CO) exposure or flame roll-out may occur when performing certain procedures given in this guide. See Section 1 for precautions that must be taken when conducting such procedures.

Referenced Documents

ASTM Standards

D1356 Terminology Relating to Sampling and Analysis of Atmospheres
E631 Terminology of Building Constructions
E779 Test Method for Determining Air Leakage Rate by Fan Pressurization
E1827 Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door
CGSB Standard
51.71 The Spillage Test – Method to Determine the Potential for Pressure-Induced Spillage from Vented, Fuel-Fired; Space Heating Appliances; Water Heaters, and Fireplaces

ANSI Standard
Z21.47 Gas-fired Central Furnace

NFPA Standard
54 National Fuel Gas Code
NFPA 720 Standard for the Installation of Carbon Monoxide (CO) Detection and Warning Equipment

The 2009 NFPA 720's broader scope alerts people to dangerous carbon monoxide levels in all types of structures.

The completely revised 2009 NFPA 720 Standard for the Installation of Carbon Monoxide (CO) Detection and Warning Equipment expands requirements beyond dwelling units to apply to all buildings and structures, including hotels, rooming houses, dormitories, day care facilities, schools, hospitals, assisted living facilities and nursing homes. Provisions cover the installation, location, performance, inspection, testing and maintenance of carbon monoxide detection and warning equipment.

Updated rules for dwelling units include new requirements for:

- Locating carbon monoxide alarms/detectors on every level (in addition to outside sleeping areas)
- Battery backup for electrically powered units in new homes
- Interconnection of CO alarms in new homes to assure early warning of occupants at all levels
SUMMARY OF STANDARDS REFERENCED:
CRAWL SPACES AND BASEMENTS
ASTM C1193 - 09 Standard Guide for Use of Joint Sealants

Significance and Use

This guide provides information and guidelines for consideration by the designer or applicator of a joint seal. It explains the properties and functions of various materials such as sealant, sealant backing and primer, among others; and, procedures such as substrate cleaning and priming, and installation of the components of a sealed joint. It presents guidelines for the use and application of the various materials, design of a sealant joint for a specific application and environmental conditions and effects that are known to detrimentally affect a sealant joint. The information and guidelines are also useful for those who supply accessories to the sealant industry and for those who install sealants and accessory materials associated with sealant use.

In addition to the design and installation data in this guide, consult the sealant manufacturer about applications for products and proper use and installation. Considering the range of properties of commercially available sealants, the variety of joint designs possible and the many conditions of use, the information contained herein is general in nature.

To assist the user of the guide in locating specific information, a detailed listing of guide numbered sections and their descriptors is included in Appendix X2.

1. Scope

1.1 This guide describes the use of a cold liquid-applied sealant for joint sealing applications, including joints on buildings and related adjacent areas such as plazas, decks and pavements for vehicular or pedestrian use, and types of construction other than highways and airfield pavements and bridges. Information in this guide is primarily applicable to a single- and multi-component, cold liquid-applied joint sealant and secondarily to a procured sealant when used with a properly prepared joint opening and substrate surfaces.

1.2 An elastomeric or non-elastomeric sealant described by this guide should meet the requirements of Specification C 834, C 920 or C 1311.

1.3 This guide does not provide information or guidelines for the use of a sealant in a structural sealant glazing application. Guide C 1401 should be consulted for this information. Additionally, it also does not provide information or guidelines for the use of a sealant in an insulating glass unit edge seal used in a structural sealant glazing application. Guide C 1249 should be consulted for this information.

1.4 Practice C 919 should be consulted for information and guidelines for the use of a sealant in an application when an acoustic joint seal is required.

1.5 This guide also does not provide information relative to the numerous types of sealant that are available, nor specific generic sealant properties such as hardness, tack-free time or curing.
process, among others. Guide C 1299 should be consulted for information on generally accepted comparative values for the characteristics and properties of the more common generic types of liquid-applied sealant.

1.6 The values stated in SI units are to be regarded as the standard. The values given in the parentheses are provided for informational purposes only.

1.7 The committee with jurisdiction for this standard is not aware of any comparable standards published by other organizations.

1.8 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Referenced Documents

ASTM Standards
C510 Test Method for Staining and Color Change of Single- or Multi-component Joint Sealants
C717 Terminology of Building Seals and Sealants
C719 Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)
C792 Test Method for Effects of Heat Aging on Weight Loss, Cracking and Chalking of Elastomeric Sealants
C794 Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
C834 Specification for Latex Sealants
C919 Practice for Use of Sealants in Acoustical Applications
C920 Specification for Elastomeric Joint Sealants
C1083 Test Method for Water Absorption of Cellular Elastomeric Gaskets and Sealing Materials
C1087 Test Method for Determining Compatibility of Liquid-Applied Sealants with Accessories Used in Structural Glazing Systems
C1135 Test Method for Determining Tensile Adhesion Properties of Structural Sealants
C1247 Test Method for Durability of Sealants Exposed to Continuous Immersion in Liquids
C1248 Test Method for Staining of Porous Substrate by Joint Sealants
C1249 Guide for Secondary Seal for Sealed Insulating Glass Units for Structural Sealant Glazing Applications
C1253 Test Method for Determining the Outgassing Potential of Sealant Backing
C1299 Guide for Use in Selection of Liquid-Applied Sealants
C1311 Specification for Solvent Release Sealants
C1330 Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants
C1401 Guide for Structural Sealant Glazing
C1442 Practice for Conducting Tests on Sealants Using Artificial Weathering Apparatus
C1472 Guide for Calculating Movement and Other Effects When Establishing Sealant Joint...
Width

D2203 Test Method for Staining from Sealants

Significance and Use

Air infiltration into the conditioned space of a building accounts for a significant portion of the thermal space condition load. Air infiltration can affect occupant comfort by producing drafts, causing indoor air quality problems by carrying outdoor pollutants into occupied building space and, in hot humid climates, depositing moisture in the building envelope, which deteriorates envelope components. In cold climates, exfiltration of conditioned air out of a building can deposit moisture in the building envelope causing deterioration of building envelope components. Differential pressure across the building envelope and the presence of air leakage sites cause air infiltration and exfiltration (1).

In some buildings, restricting air movement between interior zones of a building may be desired to separate dissimilar interior environments or prevent the movement of pollutants. Although not dealt with specifically in this standard, the detection practices presented can also be useful in detecting air leaks between interior zones of the building.

Air leakage sites are often difficult to locate because air flows may be small under the prevailing weather conditions. Wind conditions can aid in air leakage detection by forcing air to enter a building; however, where air is exiting, the building envelope construction may make observations difficult. For these reasons, forced pressurization or depressurization is strongly recommended for those practices which require controlled flow direction.

The techniques for air leakage site detection covered in these practices allow for a wide range of flexibility in the choice of techniques that are best suited for detecting various types of air leakage sites in specific situations.

The infrared scanning technique for air leakage site detection has the advantage of rapid surveying capability. Entire building exterior surfaces or inside wall surfaces can be covered with a single scan or a simple scanning action, provided there are no obscuring thermal effects from construction features or incident solar radiation. The details of a specific air leakage site may then be probed more closely by focusing on the local area. Local leak detection is well addressed with the smoke tracer, anemometer, sound detection, the bubble detection, and the tracer gas techniques, however these techniques are time consuming for large surfaces. The pressurized or depressurized test chamber and smoke tracer or a depressurized test chamber and leak detection liquid practices can be used in situations where depressurizing or pressurizing the entire envelope is impractical, such as is the case during construction. Both of the practices enable the detection of very small leaks. To perform these practices requires that the air barrier system be accessible.

Complexity of building air leakage sites may diminish the ability for detection. For example, using the sound detection approach, sound may be absorbed in the tortuous path through the
insulation. Air moving through such building leakage paths may lose some of its temperature differential and thus make thermographic detection difficult. The absence of jet-like air flow at an air leakage site may make detection using the anemometer practice difficult.

Stack effect in multistory commercial buildings can cause gravity dampers to stand open. Computer-controlled dampers should be placed in normal and night modes to aid in determining the conditions existing in the building. Sensitive pressure measurement equipment can be used for evaluating pressure levels between floors and the exterior. Monitoring systems in high-tech buildings can supply qualitative data on pressure differences.

1. Scope

1.1 These practices cover standardized techniques for locating air leakage sites in building envelopes and air barrier systems.

1.2 These practices offer a choice of means for determining the location of air leakage sites with each offering certain advantages for specific applications.

1.3 Some of the practices require a knowledge of infrared scanning, building and test chamber pressurization and depressurization, smoke generation techniques, sound generation and detection, and tracer gas concentration measurement techniques.

1.4 The practices described are of a qualitative nature in determining the air leakage sites rather than determining quantitative leakage rates.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific hazard statements, see Section 6.

Referenced Documents

ASTM Standards
E631 Terminology of Building Constructions
E741 Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution
E779 Test Method for Determining Air Leakage Rate by Fan Pressurization

Other Standards
ISO Standard 6781 Thermal Insulation--Qualitative Detection of Thermal Irregularities in Building Envelopes--Infrared Method

Significance and Use

Vapor inhalation is the primary hazard encountered in the use of chlorinated solvents. The greatest potential for overexposure to these solvent vapors occurs where the employee is exposed to the high concentrations of vapor that may be found in confined areas. The seriousness of this hazard is often underestimated by those performing this type of work.

This practice is designed for use by employers in developing their own specific standards for vessel or confined area entry.

Many of these areas are considered as permit-required confined spaces as defined by OSHA (29 CFR 1910.146). The determination of the applicability of these requirements is the responsibility of the user.

This practice represents the minimum requirements for entry into any confined area containing halogenated solvents.

This practice does not address all of the requirements contained in the OSHA confined spaces standard. Development and implementation of training programs, recordkeeping, and other additional requirements of the OSHA standard are the responsibility of the user.

1. Scope

1.1 This practice covers recognized procedures necessary to protect the health and safety of workers required to enter confined spaces. These procedures are particularly applicable to entry into the confined areas associated with the use of halogenated organic solvents.

1.2 Confined areas addressed in this practice include, but are not limited to: vapor degreasers, cold cleaning tanks, storage vessels, tank cars and trucks, van trailers, ships or barges, pits or sumps, and unventilated rooms.

1.3 This practice does not necessarily address entry into all confined spaces nor does it address the decision strategy involved in requiring such entry.

1.4 Although this practice describes specific safety steps to be taken for entry into confined spaces, it is not intended to preclude the use of any additional measures that may be deemed necessary for a particular situation.

1.5 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.
OSHA Technical Manual Section VIII: Chapter 1, part III PROTECTIVE CLOTHING
SELECTION FACTORS.

A. CLOTHING DESIGN. Manufacturers sell clothing in a variety of styles and configurations.

1. Design Considerations.
   - Clothing configuration;
   - Components and options;
   - Sizes;
   - Ease of donning and doffing;
   - Clothing construction;
   - Accommodation of other selected ensemble equipment;
   - Comfort; and
   - Restriction of mobility.

B. MATERIAL CHEMICAL RESISTANCE. Ideally, the chosen material(s) must resist permeation, degradation, and penetration by the respective chemicals.

1. Permeation is the process by which a chemical dissolves in or moves through a material on a molecular basis. In most cases, there will be no visible evidence of chemicals permeating a material.

   Permeation breakthrough time is the most common result used to assess material chemical compatibility. The rate of permeation is a function of several factors such as chemical concentration, material thickness, humidity, temperature, and pressure. Most material testing is done with 100% chemical over an extended exposure period. The time it takes chemical to permeate through the material is the breakthrough time. An acceptable material is one where the breakthrough time exceeds the expected period of garment use. However, temperature and pressure effects may enhance permeation and reduce the magnitude of this safety factor. For example, small increases in ambient temperature can significantly reduce breakthrough time and the protective barrier properties of a protective clothing material.

2. Degradation involves physical changes in a material as the result of a chemical exposure, use, or ambient conditions (e.g., sunlight). The most common observations of material degradation are discoloration, swelling, loss of physical strength, or deterioration.

3. Penetration is the movement of chemicals through zippers, seams, or imperfections in a protective clothing material.
It is important to note that no material protects against all chemicals and combinations of chemicals, and that no currently available material is an effective barrier to any prolonged chemical exposure.

4. Sources of information include:

- **Guidelines for the Selection of Chemical Protective Clothing, 3rd Edition.** This reference provides a matrix of clothing material recommendations for approximately 500 chemicals based on an evaluation of chemical resistance test data, vendor literature, and raw material suppliers. The major limitation for these guidelines are their presentation of recommendations by generic material class. Numerous test results have shown that similar materials from different manufacturers may give widely different performance. That is to say manufacturer A’s butyl rubber glove may protect against chemical X, but a butyl glove made by manufacturer B may not.

- **Quick Selection Guide to Chemical Protective Clothing.** Pocket size guide that provides chemical resistance data and recommendations for 11 generic materials against over 400 chemicals. The guide is color-coded by material-chemical recommendation. As with the "Guidelines..." above, the major limitation of this reference is its dependence on generic data.

- **Vendor data or recommendations.** The best source of current information on material compatibility should be available from the manufacturer of the selected clothing. Many vendors supply charts which show actual test data or their own recommendations for specific chemicals. However, unless vendor data or the recommendations are well documented, end users must approach this information with caution. Material recommendations must be based on data obtained from tests performed to standard ASTM methods. Simple ratings of "poor," "good," or "excellent" give no indication of how the material may perform against various chemicals.

5. Mixtures of chemicals can be significantly more aggressive towards protective clothing materials than any single chemical alone. One permeating chemical may pull another with it through the material. Very little data is available for chemical mixtures. Other situations may involve unidentified substances. In both the case of mixtures and unknowns, serious consideration must be given to deciding which protective clothing is selected. If clothing must be used without test data, garments with
materials having the broadest chemical resistance should be worn, i.e. materials which demonstrate the best chemical resistance against the widest range of chemicals.

C. PHYSICAL PROPERTIES.

1. As with chemical resistance, manufacturer materials offer wide ranges of physical qualities in terms of strength, resistance to physical hazards, and operation in extreme environmental conditions. Comprehensive manufacturing standards such as the NFPA Standards set specific limits on these material properties, but only for limited applications, i.e. emergency response.

2. End users in other applications may assess material physical properties by posing the following questions:

- Does the material have sufficient strength to withstand the physical strength of the tasks at hand?
- Will the material resist tears, punctures, cuts, and abrasions?
- Will the material withstand repeated use after contamination and decontamination?
- Is the material flexible or pliable enough to allow end users to perform needed tasks?
- Will the material maintain its protective integrity and flexibility under hot and cold extremes?
- Is the material flame-resistant or self-extinguishing (if these hazards are present)?
- Are garment seams in the clothing constructed so they provide the same physical integrity as the garment material?

D. EASE OF DECONTAMINATION. The degree of difficulty in decontaminating protective clothing may dictate whether disposable or reusable clothing is used, or a combination of both.

E. COST. Protective clothing end users must endeavor to obtain the broadest protective equipment they can buy with available resources to meet their specific application.

F. CHEMICAL PROTECTIVE CLOTHING STANDARDS. Protective clothing buyers may wish to specify clothing that meets specific standards, such as 1910.120 or the NFPA standards (see Paragraph on classification by performance). The NFPA Standards do not apply to all forms of protective clothing and applications.

- Prohibit work on new and existing energized (hot) electrical circuits until all power is shut off and a positive Lockout/Tagout System is in place.
- Don't use frayed or worn electrical cords or cables.
- Use only 3-wire type extension cords designed for hard or junior hard service. (Look for any of the following letters imprinted on the casing: S, ST, SO, STO, SJ, SJT, SJO, SJTO.)
- Maintain all electrical tools and equipment in safe condition and check regularly for defects.
- Remove broken or damaged tools and equipment from the jobsite.
- Protect all temporary power (including extension cords) with ground fault circuit interrupters (GFCIs). Plug into a GFCI-protected temporary power pole, a GFCI protected generator, or use a GFCI extension cord to protect against shocks (Figure 22).
- Don't bypass any protective system or device designed to protect employees from contact with electrical current.
- Locate and identify overhead electrical power lines. Make sure that ladders, scaffolds, equipment or materials never come within 10 feet of electrical power lines.
ASTM Moisture Control in Buildings Manual

Twenty-eight comprehensive chapters focus on the major issues involved in the process of moisture resistive construction. This publication provides the latest and most important information relating to moisture problems in buildings.

Three new chapters have been added to make this the ultimate publication on moisture control:

- Details and Practice discusses design details suitable for preventing moisture problems in service.
- Quality Management in Design and Construction discusses the need for and application of quality control and management during design and construction for preventing moisture problems in service.
- Towards Development of Methods for Assessment of Moisture-Originated Damage looks to the future.

The latest edition is divided into four parts:

**Fundamentals**—addresses moisture transfer, condensation, and evaporation.

**Applications**—discusses the technologies that affect the moisture balance in buildings and the techniques used to determine the suitability of materials, components, systems, and structures.

**Construction Principles and Recommendations**—covers new and existing commercial and high buildings, new and existing residential buildings, and manufactured and historic buildings.

**Implementation**—discusses implementation mechanisms.

IBC 1203.3.1 Openings for Under-floor Ventilation

The minimum net area of the crawlspace ventilation openings shall not be less than 1 square foot for each 150 square feet (0.67 m² for each 100 m²) of crawl-space area. Ventilation openings shall be covered for their height and width with any of the following materials, provided that the least dimension of the covering shall not exceed 1/4 inch (6 mm)

1. Perforated sheet metal plates not less than 0.070 inch (1.8 mm) thick.
2. Expanded sheet metal plates not less than 0.047 inch (1.2 mm) thick.
3. Cast-iron grilles or gratings.
4. Extruded load-bearing vents.
5. Hardware cloth of 0.035 inch (0.89 mm) wire or heavier.
6. Corrosion-resistant wire mesh, with the least dimension not exceeding 1/8 inch (3.2 mm).

**IECC SECTION 402.2.9**

Crawl space walls. As an alternative to insulating floors over crawl spaces, crawl space walls shall be permitted to be insulated when the crawl space is not vented to the outside. Crawl space wall insulation shall be permanently fastened to the wall and extend downward from the floor to the finished grade level and then vertically and/or horizontally for at least an additional 24 inches (610 mm). Exposed earth in unvented crawl space foundations shall be covered with a continuous Class I vapor retarder. All joints of the vapor retarder shall overlap by 6 inches (153 mm) and be sealed or taped. The edges of the vapor retarder shall extend at least 6 inches (153 mm) up the stem wall and shall be attached to the stem wall.
**IBC 1203.3.2 Exceptions.**

The following are exceptions to Sections 1203.3 and 1203.3.1:

1. Where warranted by climatic conditions, ventilation openings to the outdoors are not required if ventilation openings to the interior are provided.

2. The total area of ventilation openings is permitted to be reduced to 1/1500 of the under-floor area where the ground surface is treated with an approved vapor retarder material and the required openings are placed so as to provide cross ventilation of the space.

3. Ventilation openings are not required where continuously operated mechanical ventilation is provided at a rate of one cubic foot per minute for each fifty square feet of crawl-space floor area and the ground surface is covered with an approved vapor retarder.

Ventilation openings are not required when the ground surface is covered with an approved vapor retarder, the perimeter walls are insulated and the space is conditioned in accordance with the International Energy Conservation Code.
ASTM E241 - 09 Standard Guide for Limiting Water-Induced Damage to Buildings

Significance and Use

Moisture degradation is frequently a significant factor that either limits the useful life of a building or necessitates costly repairs. Examples of moisture degradation include: (1) decay of wood-based materials, (2) spalling of masonry caused by freeze-thaw cycles, (3) damage to gypsum plasters by dissolution, (4) corrosion of metals, (5) damage due to expansion of materials or components (by swelling due to moisture pickup, or by expansion due to corrosion, hydration, or delayed ettringite formation), (6) spalling and degradation caused by salt migration, (7) failure of finishes, and (8) creep deformation and reduction in strength or stiffness.

Moisture accumulation within construction components or constructions may adversely affect serviceability of a building, without necessarily causing immediate and serious degradation of the construction components. Examples of such serviceability issues are: (1) indoor air quality, (2) electrical safety, (3) degradation of thermal performance of insulations, and (4) decline in physical appearance. Mold or mildew growth can influence indoor air quality and physical appearance. With some components, in particular interior surface finishes, mold or mildew growth may limit service life of the component. Moisture conditions that affect serviceability issues can frequently be expected, unless corrected, to eventually result in degradation of the building or its components. This guide does not attempt however to address serviceability issues that could be corrected by cleaning and change in building operation, and that would not require repair or replacement of components to return the building (or portions or components of the building) to serviceability.

Prevention of water-induced damage must be considered throughout the construction process including the various stages of the design process, construction, and building commissioning. It must also be considered in building operation and maintenance, and when the building is renovated, rehabilitated or undergoes a change in use.

This guide is intended to alert designers and builders, and also building owners and managers, to potential damages that may be induced by water, regardless of its source. This guide discusses moisture sources and moisture migration. Limit states (or specific moisture conditions that are likely to impact construction or component durability) and design methods are also cursorily discussed. Examples of practices that enhance durability are listed and discussed, as are examples of constructions or circumstances to avoid. The examples listed are not all-inclusive. Lastly, field check lists are given. The checklists are not intended for use as is, but as guides for development of checklists which may vary with specific building designs and climates.
1. Scope

1.1 This guide concerns building design, construction, commissioning, operation, and maintenance.

1.2 This guide addresses the need for systematic evaluation of factors that can result in moisture-induced damage to a building or its components. Although of great potential importance, serviceability issues which are often, but not necessarily, related to physical damage of the building or its components (for example, indoor air quality or electrical safety) are not directly addressed in this guide.

1.3 The emphasis of this guide is on low-rise buildings. Portions of this guide; in particular Sections 5, 6, and 7; may also be applicable to high-rise buildings.

1.4 This guide is not intended for direct use in codes and specifications. It does not attempt to prescribe acceptable limits of damage. Buildings intended for different uses may have different service life expectancies, and expected service lives of different components within a given building often differ. Furthermore, some building owners may be satisfied with substantially shorter service life expectancies of building components or of the entire building than other building owners. Lastly, the level of damage that renders a component unserviceable may vary with the type of component, the degree to which failure of the component is critical (for example, whether failure constitutes a life-safety hazard), and the judgement (that is, tolerance for damage) of the building owner. For the reasons stated in this paragraph, prescribing limits of damage would require listing many pages of exceptions and qualifiers and is beyond the scope of this guide.

1.5 This standard does not purport to address the safety concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Referenced Documents

ASTM Standards
C168 Terminology Relating to Thermal Insulation
C717 Terminology of Building Seals and Sealants
C755 Practice for Selection of Water Vapor Retarders for Thermal Insulation
C1193 Guide for Use of Joint Sealants
D1079 Terminology Relating to Roofing and Waterproofing
E331 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
E547 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference
E631 Terminology of Building Constructions
E1105 Test Method for Field Determination of Water Penetration of Installed Exterior Windows,

Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference

E1643 Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs

E1677 Specification for an Air Barrier (AB) Material or System for Low-Rise Framed Building Walls

E1745 Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs

E2112 Practice for Installation of Exterior Windows, Doors and Skylights


Other Documents

ASTM C1136 - 10 Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation

Abstract

This specification covers vapor retarders for thermal insulation, specifically, flexible materials with permeance and surface burning characteristics. Vapor retarders are classified based on vapor retardance and strength properties: Types I, II, III, IV, V, and VI. The following test methods shall be performed: water vapor permeance; surface burning characteristics; tensile strength; dimensional stability; fungi resistance; thermal integrity of flexible water vapor retarders; burst strength of vapor retarders; permanence of flame retardancy; and elevated temperature and humidity resistance of vapor retarders for insulation.

This abstract is a brief summary of the referenced standard. It is informational only and not an official part of the standard; the full text of the standard itself must be referred to for its use and application. ASTM does not give any warranty express or implied or make any representation that the contents of this abstract are accurate, complete or up to date.

Significance and Use

Entrapment of water in thermal insulation caused by condensation of water vapor that has penetrated into the insulation is detrimental to the thermal resistance of the insulation. For this reason, in certain installations where temperature and moisture conditions have the potential to create a vapor driving force toward the insulation, a deterrent to the passage of such vapor into the installed insulation needs to be provided. This is the primary function of the vapor retarder.

In addition to the function stated in 9.1, a vapor retarder has the potential to provide physical protection and added strength to the insulation system.

This specification is used to specify material by physical property requirements that address the above prerequisites. The designer of an insulation system, after determining the degree of protection needed for the insulation, can use this specification to specify the appropriate type of vapor retarder when one is required.

1. Scope

1.1 This specification covers vapor retarders for thermal insulation, specifically, flexible materials with permeance of 0.10 perm or lower and surface burning characteristics of 25 flame spread/50 smoke or lower. These materials are intended for use at surface temperatures of −20 to 150°F (−29 to 66°C). It does not cover mastics or barrier coatings applied in liquid form, nor materials intended for use as weather barriers.
1.2 This is a material specification and does not imply that an installed system using these materials will provide the physical properties specified in Section 6.

1.3 This specification provides physical requirements for vapor retarders. Practice C755 provides assistance in solving problems related to moisture vapor transmission through thermal insulation materials.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 The following precautionary caveat pertains to the test methods portion only, Section 10, of this specification: This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Referenced Documents

**ASTM Standards**
- C168 Terminology Relating to Thermal Insulation
- C755 Practice for Selection of Water Vapor Retarders for Thermal Insulation
- C1258 Test Method for Elevated Temperature and Humidity Resistance of Vapor Retarders for Insulation
- C1263 Test Method for Thermal Integrity of Flexible Water Vapor Retarders
- C1338 Test Method for Determining Fungi Resistance of Insulation Materials and Facings
- D882 Test Method for Tensile Properties of Thin Plastic Sheeting
- D1204 Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature
- E84 Test Method for Surface Burning Characteristics of Building Materials
- E96/E96M Test Methods for Water Vapor Transmission of Materials

**TAPPI Standards**
- T461 Flame Resistance of Treated Paper and Paperboard
ASTM E1643 - 09 Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs

Significance and Use

Vapor retarders provide a method of limiting water vapor transmission and capillary transport of water upward through concrete slabs on grade, which can adversely affect floor finishes and interior humidity levels.

Adverse impacts include adhesion loss, warping, peeling, and unacceptable appearance of resilient flooring; deterioration of adhesives, ripping or separation of seams, and air bubbles or efflorescence beneath seamed, continuous flooring; damage to flat electrical cable systems, buckling of carpet and carpet tiles, offensive odors, growth of fungi, and undesired increases to interior humidity levels.

1. Scope

1.1 This practice covers procedures for selecting, designing, installing, and inspecting flexible, prefabricated sheet membranes in contact with earth or granular fill used as vapor retarders under concrete slabs.

1.2 Conditions subject to frost and either heave or hydrostatic pressure, or both, are beyond the scope of this practice. Vapor retarders are not intended to provide a waterproofing function.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Referenced Documents

ASTM Standards
E1745 Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs
E1993 Specification for Bituminous Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs
F710 Practice for Preparing Concrete Floors to Receive Resilient Flooring
Other Standard
ACI302.2R–06 Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials

Section 5
5.1 Level or tamp or roll granular base.
5.2 Place vapor retarder with the longest dimension parallel with the direction of the pour.
5.3 Lap vapor retarder over footings or seal to foundation walls or both, and seal all penetrations such as utilities and columns in order to create a monolithic membrane between the surface of the slab and moisture sources below the slab and at the slab perimeter (see Fig 1-3).
5.4 Lap joints 6 in. (150 mm) or as instructed by the manufacturer and seal with the manufacturer's recommended adhesive or pressure sensitive tape or both.

Section 6.4
6.4 Avoid use of stakes driven through the vapor retarder

1. Scope

1.1 This guide describes and compares different methods for assessing the potential for, or existence of, depressurization-induced backdrafting and spillage from vented residential combustion appliances.

1.2 Assessment of depressurization-induced backdrafting and spillage is conducted under either induced depressurization or natural conditions.

1.3 Residential vented combustion appliances addressed in this guide include hot water heaters and furnace. The guide also is applicable to boilers.

1.4 The methods given in this guide are applicable to Category I (draft-hood- and induced-fan-equipped) furnaces. The guide does not apply to Category III (power-vent-equipped) or Category IV (direct-vent) furnaces.

1.5 The methods in this guide are not intended to identify backdrafting or spillage due to vent blockage or heat-exchanger leakage.

1.6 This guide is not intended to provide a basis for determining compliance with code requirements on appliance and venting installation, but does include a visual assessment of the installation. This assessment may indicate the need for a thorough inspection by a qualified technician.

1.7 Users of the methods in this guide should be familiar with combustion appliance operation and with making house-tightness measurements using a blower door. Some methods described in this guide require familiarity with differential-pressure measurements and use of computer-based data-logging equipment.

This guide does not purport to address all safety concerns, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use. Carbon monoxide (CO) exposure or flame roll-out may occur when performing certain procedures given in this guide. See Section 1, for precautions that must be taken in conducting such procedures.

Referenced Documents

ASTM Standards
D1356 Terminology Relating to Sampling and Analysis of Atmospheres
E631 Terminology of Building Constructions
E779 Test Method for Determining Air Leakage Rate by Fan Pressurization
E1827 Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door

CGSB Standard
51.71 The Spillage Test--Method to Determine the Potential for Pressure-Induced Spillage from Vented, Fuel-Fired; Space Heating Appliances; Water Heaters, and Fireplaces

ANSI Standard
Z21.47 Gas-fired Central Furnace

NFPA Standard
54 National Fuel Gas Code
ASTM C 1320-05 (09) Standard Practice for Installation of Mineral Fiber Batt and Blanket Insulation Thermal Insulation for Light Frame Construction

Significance and Use

This practice recognizes that effectiveness, safety, and durability of insulation depend not only on the quality of the insulating materials but also on their proper installation.

This practice provides general procedures that will help to ensure installation of insulation in a safe and effective manner. It shall be noted that actual conditions in existing buildings vary greatly and in some cases additional care shall be taken to ensure effective and safe installation.

1. Scope

1.1 This practice covers procedures for the installation of mineral fiber batt and blanket thermal insulation in ceilings, attics, floors, and walls of new or existing housing and other light frame construction.

1.2 This practice covers the installation process from pre-installation inspection through post-installation inspection. It does not cover the production of the insulation materials.

1.3 This practice is not intended to replace manufacturers’ installation instructions, but it shall be used in conjunction with such instructions. This practice is not intended to supersede local, state, or federal codes.

1.4 This practice assumes that the installer possesses a working knowledge of applicable codes and regulations, safety practices, tools, equipment, and methods necessary for the installation of thermal insulation materials. It also assumes that the installer understands the fundamentals of construction that affect the installation of insulation.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.
IECC Chapter 3 Climate Zones

- Marine (C)
- Dry (B)
- Moist (A)

Warm-Humid below white line

Zone 1 includes:
- Hawaii
- Guam
- Puerto Rico
- and the Virgin Islands

All of Alaska in Zone 2 except for the following Boroughs in Zone 3:
- Bethel
- Dillingham
- Fairbanks North Star
- Nome
- North Slope
- Northwest Arctic
- Southeast Fairbanks
- Wade Hampton
- Yukon-Koyukuk

DRAFT FOR PUBLIC REVIEW
ASTM E1465 - 08a Standard Practice for Radon Control Options for the Design and Construction of New Low-Rise Residential Buildings

Abstract

This practice provides the design details and construction methods for two built-in soil depressurization radon control and reduction systems appropriate for use in new low-rise residential buildings. Depending on the configuration of the radon vent stack installed, the radon system's operation may have a pipe route appropriate for a fan-powered radon reduction system, or have a more efficient pipe route appropriate for passively operated radon reduction systems. This practice covers special features for soil depressurization radon reduction systems including (1) slab-on-grade, basement and crawlspace foundation types with cast concrete slab and membrane ground covers, (2) sub-slab and submembrane gas-permeable layers and their drainage, (3) radon system piping, (4) radon discharge separation from openings into occupiable space, (5) radon fan installation, (6) electrical requirements, (7) radon system monitor installation, (8) labeling, (9) radon testing, and (10) system documentation.

This abstract is a brief summary of the referenced standard. It is informational only and not an official part of the standard; the full text of the standard itself must be referred to for its use and application. ASTM does not give any warranty express or implied or make any representation that the contents of this abstract are accurate, complete or up to date.

Significance and Use

Fan-powered radon reduction systems built into new residential buildings according to this practice are likely to reduce elevated indoor radon levels, where soil-gas is the source of radon, to below 2.0 picocuries per litre (pCi/L) (75 becquerels of radon per cubic metre (Bq/m³)) in occupiable spaces. Passive radon reduction systems do not always reduce such indoor radon concentrations to below 2.0 picocuries per litre (pCi/L) (75 becquerels of radon per cubic metre (Bq/m³)) in occupiable spaces. When a passive system, built according to this practice, does not achieve acceptable radon concentrations, that system should be converted to fan-powered operation to significantly improve its performance. Exceptions—New residential buildings built on expansive soil and karst may require additional measures, not included in this practice, to achieve acceptable radon reduction. Consider consulting with a soil/geotechnical specialist, a qualified foundation structural engineer and contacting the state’s radon in air specialist for up-to-date information about construction methods. Names of your state radon specialist are available from the U.S. EPA website (http://www.epa.gov/radon).

Note 1—Residences using private wells can have elevated indoor radon concentrations due to radon that out-gasses from the water used indoors, like water used to shower (7). Consider contacting your state’s radon specialist for up-to-date information on available methods for removing radon from private well water.
All soil depressurization radon reduction methods require a gas-permeable layer which can be depressurized. The gas-permeable layer is positioned under the building’s sealed ground cover. In the case of the active soil depressurization system, a radon fan pulls air up the vent stack to depressurize the gas-permeable layer. In the case of a passive soil depressurization system, when air in the vent stack is warmer than that outdoors, the warmer air rises in the stack causing the gas-permeable layer to be depressurized. The passive system depressurizes the gas-permeable layer intermittently; the fan-powered system depressurizes the gas-permeable layer continuously. The performance of gas-permeable layers depends on their design; see 6.4.1.3. A radon reduction system that operates passively requires the most efficient gas-permeable layer.

U.S. EPA recommended action level concerning indoor radon states that the radon concentration should always be reduced if it is 4 picocuries per litre (pCi/L) (150 becquerels of radon per cubic metre (Bq/m³)) or above in occupiable spaces. According to U.S. EPA there is also reduced risk when radon concentrations in indoor air are lowered to below 2.0 picocuries per litre (pCi/L) (75 becquerels of radon per cubic metre (Bq/m³)) in occupiable spaces (4).

Significant benefit is obtained from reducing indoor radon concentrations to below 4 pCi/L (150 Bq/m³). According to the U.S. EPA’s risk assessment (8), about 62 out of 1000 people who smoke will die from a lifetime’s average radon exposure of 4 pCi/L (150 Bq/m³); for people who never smoked about 7 out of 1000 will people die from the same lifetime exposure. Smokers’ lifetime risk of death from lung cancer is reduced by about half (50 %) when their average radon exposure is reduced from 4 to 2 pCi/L (150 to 75 Bq/m³); their risk is reduced by about two-thirds (67 %) when their exposure is reduced from 4 to 1.3 pCi/L (150 to 75 Bq/m³). Never-smokers’ lifetime risk of death from lung cancer is reduced by about 40 % when their average radon exposure is reduced from 4 to 2 pCi/L (150 to 75 Bq/m³); the risk is reduced by 70 % when their exposure is reduced from 4 to 1.3 pCi/L (150 to 50 Bq/m³). U.S. EPA recommended action level about reducing radon to less that 4 pCi/L (150 Bq/m³) is “Radon levels less than 4 pCi/L (150 Bq/m³) still pose a risk, and in many cases may be reduced” (4). U.S. EPA recommendation is to “Consider fixing between 2 and 4 pCi/L (75 and 150 Bq/m³).” (See radon reduction goals in 1.4 and 6.11.4.)

This practice assumes that the customer is informed about the risks of lung cancer from exposure to radon and able to establish by contract the maximum acceptable indoor radon concentration allowed in the new residential building. Because there are goals and recommended action level but no government mandated maximum indoor radon concentration for new residential construction in the United States customers and their agents should negotiate to establish by contract the maximum acceptable indoor radon concentration. The customer should keep in mind that the building’s indoor radon concentration can never be less than the radon concentration in the outdoor air in the vicinity of the building; that establishing target radon levels below 2 pCi/L (75 Bq/m³) could be more expensive; and that radon concentrations below 2 pCi/L (75 Bq/m³) are difficult to measure using current commercially available technology. (See (4, 7), 1.4, and 6.11.4.)
The negotiated acceptable radon concentration defined by this standard can vary from customer to customer and contract to contract. The owner’s goal for radon reduction should be known and considered before the radon system design is specified. The construction choices for void space in the gas-permeable layer; vent stack pipe diameter and route; radon fan capacity; and building features influence the radon reduction system’s performance. (See 1.4, 3.2.1, 5.3, 5.4, 5.5, and 6.4.1.3.)

This practice offers organized information about radon reduction methods. This practice cannot replace education and experience and should be used in conjunction with trained and certified radon practitioner’s judgment. Not all aspects of this practice may be applicable in all circumstances.

This practice is not intended, by itself, to replace the standard of care by which adequacy of a professional service may be judged, nor should this practice alone be applied without consideration of a project’s unique aspects.

The word “Standard” in the title of this practice means that the document has been approved through the ASTM consensus process.

Reliable methods for predicting indoor radon concentrations for a particular residential building prior to its construction are not available at this time. If the house is in contact with the ground, it is possible for radon gas to be present. Not all houses will need a radon system; nationally, 1 out of 15, or 7% of the houses have indoor radon concentrations greater than 4 pCi/L (150 Bq/m³). In the highest state 71% of the houses have indoor radon greater than 4 pCi/L (150 Bq/m³). In fifteen states less than 10% of the houses are over 4 pCi/L (150 Bq/m³). In six states 40% or more of the houses have indoor radon over 4 pCi/L (150 Bq/m³). State and local jurisdictions and individual owners are in the best position to decide where houses with radon reduction features should be built.

1. Scope

1.1 This practice covers the design and construction of two radon control options for use in new low-rise residential buildings. These unobtrusive (built-in) soil depressurization options are installed with a pipe route appropriate for their intended initial mode of operation, that is, fan-powered or passive. One of these pipe routes should be installed during a residential building’s initial construction. Specifications for the critical gas-permeable layer, the radon system’s piping, and radon entry pathway reduction are comprehensive and common to both pipe routes.

1.1.1 The first option has a pipe route appropriate for a fan-powered radon reduction system. The radon fan should be installed after (1) an initial radon test result reveals unacceptable radon concentrations and therefore a need for an operating radon fan, or (2) the owner has specified an operating radon fan, as well as acceptable radon test results before occupancy. Fan operated soil depressurization radon systems reduce indoor radon concentrations up to 99%.
1.1.2 The second option has a more efficient pipe route appropriate for passively operated radon reduction systems. Passively operated radon reduction systems provide radon reductions of up to 50%. When the radon test results for a building with an operating passive system are not acceptable, that system should be converted to fan-powered operation. Radon systems with pipe routes installed for passive operation can be converted easily to fan-powered operation; such fan operated systems reduce indoor radon concentrations up to 99%.

1.2 The options provide different benefits:

1.2.1 The option using the pipe route for fan-powered operation is intended for builders with customers who want maximum unobtrusive built-in radon reduction and documented evidence of an effective radon reduction system before a residential building is occupied. Radon systems with fan-powered type pipe routes allow the greatest architectural freedom for vent stack routing and fan location.

1.2.2 The option using the pipe route for passive operation is intended for builders and their customers who want unobtrusive built-in radon reduction with the lowest possible operating cost, and documented evidence of acceptable radon system performance before occupancy. If a passive system’s radon reduction is unacceptable, its performance can be significantly increased by converting it to fan-powered operation.

1.3 Fan-powered, soil depressurization, radon-reduction techniques, such as those specified in this practice, have been used successfully for slab-on-grade, basement, and crawlspace foundations throughout the world.

1.4 Radon in air testing is used to assure the effectiveness of these soil depressurization radon systems. The U.S. national goal for indoor radon concentration, established by the U.S. Congress in the 1988 Indoor Radon Abatement Act, is to reduce indoor radon as close to the levels of outside air as is practicable. The radon concentration in outside air is assumed to be 0.4 picocuries per litre (pCi/l) (15 Becquerels per cubic metre (Bq/m³)); the U.S.’s average radon concentration in indoor air is 1.3 pCi/L (50 Bq/m³). The goal of this practice is to make available new residential buildings with indoor radon concentrations below 2.0 pCi/L (75 Bq/m³) in occupiable spaces.

1.5 This practice is intended to assist owners, designers, builders, building officials and others who design, manage, and inspect radon systems and their construction for new low-rise residential buildings.

1.6 This practice can be used as a model set of practices, which can be adopted or modified by state and local jurisdictions, to fulfill objectives of their residential building codes and regulations. This practice also can be used as a reference for the federal, state, and local health officials and radiation protection agencies.
1.7 The new dwelling units covered by this practice have never been occupied. Radon reduction for existing low rise residential buildings is covered by Practice E 2121, or by state and local building codes and radiation protection regulations.

1.8 Fan-powered soil depressurization, the principal strategy described in this practice, offers the most effective and most reliable radon reduction of all currently available strategies. Historically, far more fan-powered soil depressurization radon reduction systems have been successfully installed and operated than all other radon reduction methods combined. These methods are not the only methods for reducing indoor radon concentrations (1-3).

1.9 Section 7 is Occupational Radon Exposure and Worker Safety.

1.10 Appendix X1 is Principles of Operation for Fan-Powered Soil Depressurization Radon Reduction.

1.11 Appendix X2 is a Summary of Practice E 1465 Requirements for Installation of Radon Reduction Systems in New Low Rise Residential Building.

1.12 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.13 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Referenced Documents

ASTM Standards
C29/C29M Test Method for Bulk Density (Unit Weight) and Voids in Aggregate
C127 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
D1785 Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
D2241 Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
D2466 Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
D2665 Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
D2729 Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
D2751 Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings
E631 Terminology of Building Constructions
E1643 Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs
E1745 Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs
E2121 Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings
F405 Specification for Corrugated Polyethylene (PE) Pipe and Fittings
F628 Specification for Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe With a Cellular Core
F891 Specification for Coextruded Poly(Vinyl Chloride) (PVC) Plastic Pipe With a Cellular Core

Other Publications
Uniform Building Code, Chapters 18, 19 and 21
SUMMARY OF STANDARDS REFERENCED:

BASE LOAD
NFPA 70A: National Electrical Code® Requirements for One-and Two-Family Dwellings

Scope

(A) Covered. This Code covers the installation of electrical conductors, equipment, and raceways; signaling and communications conductors, equipment, and raceways; and optical fiber cables and raceways for the following:
(1) Public and private premises, including buildings, structures, mobile homes, recreational vehicles, and floating buildings
(2) Yards, lots, parking lots, carnivals, and industrial substations
(3) Installations of conductors and equipment that connect to the supply of electricity
(4) Installations used by the electric utility, such as office buildings, warehouses, garages, machine shops, and recreational buildings, that are not an integral part of a generating plant, substation, or control center.
National Appliance Energy Conservation Act (NAECA)

The National Appliance Energy Conservation Act (NAECA) was adopted by the U.S. Congress with virtually no opposition and was signed into law by President Reagan (U.S. Congress 1987). The standards established minimum energy efficiency requirements for 12 types of residential appliances sold in the United States. NAECA also contains requirements and deadlines for updating the initial standards through rulemakings conducted by DOE using criteria included in the law. The latest revised standards by the Department of Energy on refrigerators and freezers went into effect beginning in 2001. New standards on clothes washers went into effect on 2007, clothes dryers and dishwashers in 1994.
40 CFR 271.13 Title 40: Protection of Environment  PART 273—STANDARDS FOR UNIVERSAL WASTE MANAGEMENT

Subpart B—Standards for Small Quantity Handlers of Universal Waste

273.13 Waste management

(c) Mercury-containing equipment. A small quantity handler of universal waste must manage universal waste mercury-containing equipment in a way that prevents releases of any universal waste or component of a universal waste to the environment, as follows:

(1) A small quantity handler of universal waste must place in a container any universal waste mercury-containing equipment with non-contained elemental mercury or that shows evidence of leakage, spillage, or damage that could cause leakage under reasonably foreseeable conditions. The container must be closed, structurally sound, compatible with the contents of the device, must lack evidence of leakage, spillage, or damage that could cause leakage under reasonably foreseeable conditions, and must be reasonably designed to prevent the escape of mercury into the environment by volatilization or any other means.

(2) A small quantity handler of universal waste may remove mercury-containing ampules from universal waste mercury-containing equipment provided the handler:

(i) Removes and manages the ampules in a manner designed to prevent breakage of the ampules;

(ii) Removes the ampules only over or in a containment device (e.g., tray or pan sufficient to collect and contain any mercury released from an ampule in case of breakage);

(iii) Ensures that a mercury clean-up system is readily available to immediately transfer any mercury resulting from spills or leaks from broken ampules from that containment device to a container that meets the requirements of 40 CFR 262.34;

(iv) Immediately transfers any mercury resulting from spills or leaks from broken ampules from the containment device to a container that meets the requirements of 40 CFR 262.34;

(v) Ensures that the area in which ampules are removed is well ventilated and monitored to ensure compliance with applicable OSHA exposure levels for mercury;

(vi) Ensures that employees removing ampules are thoroughly familiar with proper waste mercury handling and emergency procedures, including transfer of mercury from containment devices to appropriate containers;

(vii) Stores removed ampules in closed, non-leaking containers that are in good condition;
(viii) Packs removed ampules in the container with packing materials adequate to prevent breakage during storage, handling, and transportation;

**NFPA 54/ANSI/AGA Z223.1 National Fuel Gas Code**

Up-to-date with current techniques, products, materials, and construction practices, the 2009 National Fuel Gas Code provides a more effective means of ensuring fuel gas safety on consumers' premises. Based on scores of proposals from Code users, it presents designers, installers, AHJs, maintainers, and inspectors of fuel gas systems in buildings with state-of-the-art criteria for the installation and operation of gas piping systems, appliances, equipment, and related accessories, including new requirements that all heating boilers have a low water cutoff switch to prevent boiler failure.

Annexes provide valuable advice on sizing and capacities of gas piping, and sizing of venting systems serving appliances...checking for leakage…and emergency procedures for gas leaks. More than 100 graphics visually clarify concepts. A new Annex provides a detailed list of all changes from the 2006 edition, with the reason for the changes.

**Contents**

- Chapter 1 Administration
- Chapter 2 Referenced Publications
- Chapter 3 Definitions
- Chapter 4 General
- Chapter 5 Gas Piping System Design, Materials, and Components
- Chapter 6 Pipe Sizing
- Chapter 7 Gas Piping Installation
- Chapter 8 Inspection, Testing, and Purging
- Chapter 9 Appliance, Equipment, and Accessory Installation
- Chapter 10 Installation of Specific Appliances
- Chapter 11 Procedures to Be Followed to Place Appliance in Operation
- Chapter 12 Venting of Appliances
- Chapter 13 Sizing of Category I Venting Systems
- Annex A Explanatory Material
- Annex B Coordination of Appliance and Equipment Design, Construction, and Maintenance
- Annex C Sizing and Capacities of Gas Piping
- Annex D Suggested Method of Checking for Leakage
- Annex E Suggested Emergency Procedure for Gas Leaks
- Annex F Flow of Gas Through Fixed Orifices
- Annex G Sizing of Venting Systems Serving Appliances Equipped with Draft Hoods, Category I Appliances, and Appliances Listed for Use with Type B Vents
- Annex H Recommended Procedure for Safety Inspection of an Existing Appliance Installation
- Annex I Indoor Combustion Air Calculation Examples
- Annex J Example of Combination of Indoor and Outdoor Combustion and Ventilation Opening Design
Annex K Other Useful Definitions
Annex L Enforcement
Annex M Informational References
Index


This standard defines the roles of and minimum requirements for mechanical and natural ventilation systems and the building envelope intended to provide acceptable indoor air quality in low-rise residential buildings. It is ASHRAE’s IAQ standard for residential buildings.

It applies to spaces intended for human occupancy within single-family houses and multi-family structures of three stories or fewer above grade, including manufactured and modular houses. This standard does not apply to transient housing such as hotels, motels, nursing homes, dormitories, or jails.

Since 2003, extensive experience has been gained in the application of this standard, due to its adoption by various building codes and use in numerous building programs. As such, many clarifications and improvements have been identified and incorporated through the approved addenda. One significant addition is the new normative appendix addressing the application of the standard to existing buildings.


1. Scope

1.1 This guide describes and compares different methods for assessing the potential for, or existence of, depressurization-induced backdrafting and spillage from vented residential combustion appliances.

1.2 Assessment of depressurization-induced backdrafting and spillage is conducted under either induced depressurization or natural conditions.

1.3 Residential vented combustion appliances addressed in this guide include hot water heaters and furnace. The guide also is applicable to boilers.

1.4 The methods given in this guide are applicable to Category I (draft-hood- and induced-fan-equipped) furnaces. The guide does not apply to Category III (power-vent-equipped) or Category IV (direct-vent) furnaces.

1.5 The methods in this guide are not intended to identify backdrafting or spillage due to vent blockage or heat-exchanger leakage.

1.6 This guide is not intended to provide a basis for determining compliance with code requirements on appliance and venting installation, but does include a visual assessment of the installation. This assessment may indicate the need for a thorough inspection by a qualified technician.

1.7 Users of the methods in this guide should be familiar with combustion appliance operation and with making house-tightness measurements using a blower door. Some methods described in this guide require familiarity with differential-pressure measurements and use of computer-based data-logging equipment.

This guide does not purport to address all safety concerns, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use. Carbon monoxide (CO) exposure or flame roll-out may occur when performing certain procedures given in this guide. See Section 1, for precautions that must be taken in conducting such procedures.

Referenced Documents

ASTM Standards
D1356 Terminology Relating to Sampling and Analysis of Atmospheres
E631 Terminology of Building Constructions
E779 Test Method for Determining Air Leakage Rate by Fan Pressurization
E1827 Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door

CGSB Standard
51.71 The Spillage Test--Method to Determine the Potential for Pressure-Induced Spillage from Vented, Fuel-Fired; Space Heating Appliances; Water Heaters, and Fireplaces

ANSI Standard
Z21.47 Gas-fired Central Furnace

NFPA Standard
54 National Fuel Gas Code
OSH Act of 1970
SEC. 5. Duties

(a) Each employer --

(1) shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees;

(2) shall comply with occupational safety and health standards promulgated under this Act.

(b) Each employee shall comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this Act which are applicable to his own actions and conduct.
ASTM E241 - 09 Standard Guide for Limiting Water-Induced Damage to Buildings

Significance and Use

Moisture degradation is frequently a significant factor that either limits the useful life of a building or necessitates costly repairs. Examples of moisture degradation include: (1) decay of wood-based materials, (2) spalling of masonry caused by freeze-thaw cycles, (3) damage to gypsum plasters by dissolution, (4) corrosion of metals, (5) damage due to expansion of materials or components (by swelling due to moisture pickup, or by expansion due to corrosion, hydration, or delayed ettringite formation), (6) spalling and degradation caused by salt migration, (7) failure of finishes, and (8) creep deformation and reduction in strength or stiffness.

Moisture accumulation within construction components or constructions may adversely affect serviceability of a building, without necessarily causing immediate and serious degradation of the construction components. Examples of such serviceability issues are: (1) indoor air quality, (2) electrical safety, (3) degradation of thermal performance of insulations, and (4) decline in physical appearance. Mold or mildew growth can influence indoor air quality and physical appearance. With some components, in particular interior surface finishes, mold or mildew growth may limit service life of the component. Moisture conditions that affect serviceability issues can frequently be expected, unless corrected, to eventually result in degradation of the building or its components. This guide does not attempt however to address serviceability issues that could be corrected by cleaning and change in building operation, and that would not require repair or replacement of components to return the building (or portions or components of the building) to serviceability.

Prevention of water-induced damage must be considered throughout the construction process including the various stages of the design process, construction, and building commissioning. It must also be considered in building operation and maintenance, and when the building is renovated, rehabilitated or undergoes a change in use.

This guide is intended to alert designers and builders, and also building owners and managers, to potential damages that may be induced by water, regardless of its source. This guide discusses moisture sources and moisture migration. Limit states (or specific moisture conditions that are likely to impact construction or component durability) and design methods are also cursorily discussed. Examples of practices that enhance durability are listed and discussed, as are examples of constructions or circumstances to avoid. The examples listed are not all-inclusive. Lastly, field check lists are given. The checklists are not intended for use as is, but as guides for development of checklists which may vary with specific building designs and climates.
1. Scope

1.1 This guide concerns building design, construction, commissioning, operation, and maintenance.

1.2 This guide addresses the need for systematic evaluation of factors that can result in moisture-induced damage to a building or its components. Although of great potential importance, serviceability issues which are often, but not necessarily, related to physical damage of the building or its components (for example, indoor air quality or electrical safety) are not directly addressed in this guide.

1.3 The emphasis of this guide is on low-rise buildings. Portions of this guide; in particular Sections 5, 6, and 7; may also be applicable to high-rise buildings.

1.4 This guide is not intended for direct use in codes and specifications. It does not attempt to prescribe acceptable limits of damage. Buildings intended for different uses may have different service life expectancies, and expected service lives of different components within a given building often differ. Furthermore, some building owners may be satisfied with substantially shorter service life expectancies of building components or of the entire building than other building owners. Lastly, the level of damage that renders a component unserviceable may vary with the type of component, the degree to which failure of the component is critical (for example, whether failure constitutes a life-safety hazard), and the judgement (that is, tolerance for damage) of the building owner. For the reasons stated in this paragraph, prescribing limits of damage would require listing many pages of exceptions and qualifiers and is beyond the scope of this guide.

1.5 This standard does not purport to address the safety concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Referenced Documents

ASTM Standards
- C168 Terminology Relating to Thermal Insulation
- C717 Terminology of Building Seals and Sealants
- C755 Practice for Selection of Water Vapor Retarders for Thermal Insulation
- C1193 Guide for Use of Joint Sealants
- D1079 Terminology Relating to Roofing and Waterproofing
- E331 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
- E547 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference
- E631 Terminology of Building Constructions
**E1105** Test Method for Field Determination of Water Penetration of Installed Exterior Windows,

Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference

**E1643** Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs

**E1677** Specification for an Air Barrier (AB) Material or System for Low-Rise Framed Building Walls

**E1745** Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs

**E2112** Practice for Installation of Exterior Windows, Doors and Skylights

**E2136** Guide for Specifying and Evaluating Performance of Single Family Attached and Detached Dwellings--Durability

**Other Documents**


- Prohibit work on new and existing energized (hot) electrical circuits until all power is shut off and a positive Lockout/Tagout System is in place.
- Don't use frayed or worn electrical cords or cables.
- Use only 3-wire type extension cords designed for hard or junior hard service. (Look for any of the following letters imprinted on the casing: S, ST, SO, STO, SJ, SJT, SJO, SJTO.)
- Maintain all electrical tools and equipment in safe condition and check regularly for defects.
- Remove broken or damaged tools and equipment from the jobsite.
- Protect all temporary power (including extension cords) with ground fault circuit interrupters (GFCIs). Plug into a GFCI-protected temporary power pole, a GFCI protected generator, or use a GFCI extension cord to protect against shocks (Figure 22).
- Don't bypass any protective system or device designed to protect employees from contact with electrical current.
- Locate and identify overhead electrical power lines. Make sure that ladders, scaffolds, equipment or materials never come within 10 feet of electrical power lines.
ASTM C1193 - 09 Standard Guide for Use of Joint Sealants

Significance and Use

This guide provides information and guidelines for consideration by the designer or applicator of a joint seal. It explains the properties and functions of various materials, such as sealant, sealant backing, and primer, among others; and, procedures such as, substrate cleaning and priming, and installation of the components of a sealed joint. It presents guidelines for the use and application of the various materials, design of a sealant joint for a specific application, and environmental conditions and effects that are known to detrimentally affect a sealant joint. The information and guidelines are also useful for those that supply accessories to the sealant industry and for those that install sealants and accessory materials associated with sealant use.

In addition to the design and installation data in this guide, consult the sealant manufacturer about applications for its products and their proper use and installation. Considering the range of properties of commercially available sealants, the variety of joint designs possible, and the many conditions of use, the information contained herein is general in nature.

To assist the user of the guide in locating specific information, a detailed listing of guide numbered sections and their descriptors are included in Appendix X2.

1. Scope

1.1 This guide describes the use of a cold liquid-applied sealant for joint sealing applications. Including joints on buildings and related adjacent areas, such as plazas, decks, and pavements for vehicular or pedestrian use, and types of construction other than highways and airfield pavements and bridges. Information in this guide is primarily applicable to a single and multi-component, cold liquid-applied joint sealant and secondarily to a precured sealant when used with a properly prepared joint opening and substrate surfaces.

1.2 An elastomeric or non-elastomeric sealant described by this guide should meet the requirements of Specification C 834, C 920, or C 1311.

1.3 This guide does not provide information or guidelines for the use of a sealant in a structural sealant glazing application. Guide C 1401 should be consulted for this information. Additionally, it also does not provide information or guidelines for the use of a sealant in an insulating glass unit edge seal used in a structural sealant glazing application. Guide C 1249 should be consulted for this information.

1.4 Practice C 919 should be consulted for information and guidelines for the use of a sealant in an application where an acoustic joint seal is required.

1.5 This guide also does not provide information relative to the numerous types of sealant that are available nor specific generic sealant properties, such as hardness, tack-free time, or curing.
process, among others. Guide C 1299 should be consulted for information on generally accepted comparative values for the characteristics and properties of the more common generic types of liquid-applied sealant.

1.6 The values stated in SI units are to be regarded as the standard. The values given in parenthesis are provided for information only.

1.7 The Committee with jurisdiction for this standard is not aware of any comparable standards published by other organizations.

1.8 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.

1.9 The committee with jurisdiction over this standard is not aware of any comparable standards published by other organizations.

**Referenced Documents**

**ASTM Standards**

C510 Test Method for Staining and Color Change of Single- or Multicomponent Joint Sealants  
C717 Terminology of Building Seals and Sealants  
C719 Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)  
C792 Test Method for Effects of Heat Aging on Weight Loss, Cracking, and Chalking of Elastomeric Sealants  
C794 Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants  
C834 Specification for Latex Sealants  
C919 Practice for Use of Sealants in Acoustical Applications  
C920 Specification for Elastomeric Joint Sealants  
C1083 Test Method for Water Absorption of Cellular Elastomeric Gaskets and Sealing Materials  
C1087 Test Method for Determining Compatibility of Liquid-Applied Sealants with Accessories Used in Structural Glazing Systems  
C1135 Test Method for Determining Tensile Adhesion Properties of Structural Sealants  
C1247 Test Method for Durability of Sealants Exposed to Continuous Immersion in Liquids  
C1248 Test Method for Staining of Porous Substrate by Joint Sealants  
C1249 Guide for Secondary Seal for Sealed Insulating Glass Units for Structural Sealant Glazing Applications  
C1253 Test Method for Determining the Outgassing Potential of Sealant Backing  
C1299 Guide for Use in Selection of Liquid-Applied Sealants  
C1311 Specification for Solvent Release Sealants  
C1330 Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants  
C1401 Guide for Structural Sealant Glazing
C1442 Practice for Conducting Tests on Sealants Using Artificial Weathering Apparatus
C1472 Guide for Calculating Movement and Other Effects When Establishing Sealant Joint Width
D2203 Test Method for Staining from Sealants
NFPA 211: Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

Widely used by architects, installers, equipment manufacturers, AHJs, and building owners, NFPA 211 provides guidelines for construction projects involving chimneys, fireplaces, vents, and solid fuel-burning appliances. Comprehensive coverage addresses everything from selection of equipment and installation to inspection and maintenance in residential, commercial, and industrial properties.

Changes in the 2010 NFPA 211: Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances include:

• Extensive revisions to and clarification of definitions
• Terminology for gas appliances is now consistent with NFPA 54: National Fuel Gas Code
• New minimum requirements for opening for rain caps and spacing of electrical wire from dryer vents

Contents

Chapter 1 Administration
Chapter 2 Referenced Publications
Chapter 3 Definitions
Chapter 4 General Requirements
Chapter 5 Selection of Chimney and Vent Types
Chapter 6 Factory-Built Chimneys and Chimney Units
Chapter 7 Masonry Chimneys
Chapter 8 Unlisted Metal Chimneys (Smokestacks) for Nonresidential Applications
Chapter 9 Chimney Connectors and Vent Connectors
Chapter 10 Vents
Chapter 11 Fireplaces
Chapter 12 Solid Fuel–Burning Appliances
Chapter 13 Maintenance
Chapter 14 Inspection of Existing Chimneys
Annex A Explanatory Material
Annex B Informational References
Index

This standard defines the roles of and minimum requirements for mechanical and natural ventilation systems and the building envelope intended to provide acceptable indoor air quality in low-rise residential buildings. It is ASHRAE's IAQ standard for residential buildings.

It applies to spaces intended for human occupancy within single-family houses and multi-family structures of three stories or fewer above grade, including manufactured and modular houses. This standard does not apply to transient housing such as hotels, motels, nursing homes, dormitories, or jails.

Since 2003, extensive experience has been gained in the application of this standard, due to its adoption by various building codes and use in numerous building programs. As such, many clarifications and improvements have been identified and incorporated through the approved addenda. One significant addition is the new normative appendix addressing the application of the standard to existing buildings.

SUMMARY OF STANDARDS REFERENCED:
WINDOWS AND DOORS
ASTM E2112 - 07 Standard Practice for Installation of Exterior Windows, Doors and Skylights

Significance and Use

This practice recognizes that the effective performance of installed fenestration products is dependent in part upon following proper installation procedures and appropriate workmanship.

This practice recognizes that the coordination of trades and proper sequencing are essential for effective fenestration installation. The general contractor shall be responsible for the necessary coordination of trades and proper construction sequencing of the installed fenestration product.

Improper installation of units contributes to excessive air, water and sound leakage, and condensation. It may promote the deterioration of wall constructions, insulation, fenestration products, and their respective finishes.

This practice presumes a working knowledge of applicable federal, state, and local codes and regulations; specifically, but not limited to required means of egress, requirements for safety glazing materials, and structural requirements of applicable codes.

This practice presumes a working knowledge of the tools, equipment, and methods necessary for the installation of specified fenestration products. It further assumes familiarity with flashing and sealing, glazing procedures, finishes where applicable, and an understanding of the fundamentals of construction that affect the installation of these units.

This practice presumes that the products that have been furnished for the installation and their locations within the structure comply with all the applicable building codes and regulations.

1. Scope

1.1 This practice covers the installation of fenestration products in new and existing construction. For the purpose of this practice, fenestration products shall be limited to windows, sliding patio-type doors, swinging patio type doors, and skylights, as used primarily in residential and light commercial buildings.

1.2 This practice assumes that the installer possesses basic woodworking skills and an understanding of wall and roof construction, sheet metal work, and joint sealant practices.

1.3 This practice attempts to instruct and familiarize the installer with the concepts of both Barrier Systems and Membrane/Drainage Systems, in order to ensure the continuity of the building envelope. This practice attempts to educate the installer, builder, architect, and other
users in the identification and understanding of the water shedding system of the building envelope.

1.4 This practice covers the installation process from pre-installation procedures through post-installation procedures, for single units or factory-mulled multiple units in a single opening. It does not cover the fabrication or assembly of multiple units, whether such fabrication takes place in a factory or at the intended installation site. The installer should check with the manufacturer of factory-assembled units for instructions for anchoring. When using field-mulled units, follow manufacturer’s recommendations and make certain that they meet applicable codes. This practice does not cover the selection of appropriate fenestration products for a given application, nor the selection of other products or systems for use in the installation.

1.5 This practice provides minimum requirements that will help to accomplish the installation of fenestration products in an effective manner. Actual conditions in buildings vary greatly and, in some cases, substantial additional precautions may be required. In the event that the manufacturer’s installation instructions provided with the product conflict with requirements of this practice, the manufacturer's instructions shall prevail. This practice is not intended to limit or exclude other new procedures that may refine or further improve the effectiveness of fenestration installation.

1.5.1 This practice is intended to be used for background information in order to develop training manuals and training programs. Further, this practice attempts to consolidate and unify the various steps of construction, tying together the various trades involved with the continuity between fenestration products and the building envelope.

1.6 The text of this practice references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this practice.

1.7 The values stated in inch-pound units are to be regarded as the standard. The values shown in parentheses are for information only.

1.8 This standard has not been created to address all issues related to every possible installation situation one might experience in the field. Furthermore, this practice does not purport to provide fail-safe installation methods, assurance or protection against installation deficiencies, or a standard by which architects can specify or ensure delivered performance.

Note 1—There are no ISO standards covering the primary subject matter of this practice.

1.9 This practice does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use. For specific precautionary statements, see Section 5, Related Procedures. Where a lead hazard is
known or suspected, refer to *ASTM Standards on Lead Hazards Associated with Buildings* and to applicable state and federal regulations. Where an asbestos hazard is known or suspected, refer to the *ASTM Manual on Asbestos Control*, and to applicable state and federal regulations.

1.10 Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Scope</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Table of Contents</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td>Referenced Documents</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Terminology</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Definitions</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>Description of Terms Specific to this Standard</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>Abbreviations</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>Significance and Use</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Related Issues and Procedures</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Continuity with the Weather Barrier Systems</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>Joints and Anchorages</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td>Moisture Entrapment</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td>Weather Resistant Barrier</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td>Weatherability</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Construction Sequence</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>Construction Damage</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td>Inspection</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>Rough Opening</td>
<td>5.9</td>
</tr>
<tr>
<td></td>
<td>Rough Opening Size</td>
<td>5.9.1</td>
</tr>
<tr>
<td></td>
<td>Insulating or Filling the Rough Opening Gap</td>
<td>5.9.2</td>
</tr>
<tr>
<td></td>
<td>Materials Protection</td>
<td>5.10</td>
</tr>
<tr>
<td></td>
<td>Cleaning and Maintenance</td>
<td>5.11</td>
</tr>
<tr>
<td></td>
<td>Dissimilar Materials</td>
<td>5.12</td>
</tr>
<tr>
<td></td>
<td>Flashing Requirements</td>
<td>5.13</td>
</tr>
<tr>
<td></td>
<td>Fastening Systems/Anchorage</td>
<td>5.14</td>
</tr>
<tr>
<td></td>
<td>Shimming</td>
<td>5.15</td>
</tr>
<tr>
<td></td>
<td>Panning Systems and Subsills for Weatherability</td>
<td>5.16</td>
</tr>
<tr>
<td></td>
<td>Pre-Installation Procedures</td>
<td>5.17</td>
</tr>
<tr>
<td></td>
<td>Sealants-Selection and Use</td>
<td>5.18</td>
</tr>
<tr>
<td></td>
<td>Window Cleaner Anchors and Related SafetyHardware</td>
<td>5.19</td>
</tr>
</tbody>
</table>
Continuity Between the Fenestration Products and Other Components of the Building Envelope 6

Water Shedding Strategies of Wall and Roof Systems 7

Concept of Surface Barrier Systems and Membrane/Drainage Systems 7.1

Surface Barrier Systems 7.1.1

Membrane/Drainage Systems 7.1.2

Identification of Systems 7.2

Installation Methods For Windows 8

Windows in Walls Utilizing a Membrane/Drainage System 8.1

Windows with Perimeter Mounting Flanges (Nail Fins) in Drainage Type Wall Construction 8.1.1

Flange Types 8.1.1.1

Selection of Installation Method 8.1.1.2

Method A 8.1.1.3.1

Method B 8.1.1.3.2

Method A1 8.1.1.3.3

Method B1 8.1.1.3.4

Non-Finned Windows in Membrane/Drainage Type Walls 8.1.2

Windows in Walls Utilizing a Barrier Wall System (Sealant Method) 8.2

Windows in Walls Utilizing an Exterior Barrier System (EIFS or Direct Applied) 8.3

Special Considerations 8.4

Aluminum Framed Windows 8.4.1

Vinyl Framed Windows 8.4.2

Replacement Window Installation 8.5

Partial Window Replacement for Existing Integral Flange Windows 8.5.1

Partial Replacement of Mill Shop Wood Windows 8.5.2

Complete Window Replacement 8.5.3

Destructive Window Replacement (Fin Type) 8.5.3.1

Non-Destructive Window Replacement (Non-Fin Type) 8.5.3.2

Installation Methods for Doors 9

Doors in Walls Utilizing a Membrane/Drainage System 9.1

Doors with Perimeter Mounting Flanges (Nailing Fins) in Drainage Type Wall Construction 9.1.1

Flange Types 9.1.1.1

Selection of Installation Method 9.1.1.2

Method A 9.1.1.4.1

Method B 9.1.1.4.2
Method A1  9.1.1.4.3
Method B1  9.1.1.4.4
Hinged Swing (Non-finned) Doors in Membrane/Drainage Type Walls  9.1.2
Installation Methods for Skylights  10
Product Types  10.1
Flashing Procedures  10.2
Aluminum/Copper Sheet Flashing  10.3
Aluminum/Copper Step Flashing (Fabricated or Engineered)  10.4
Membrane Flashing  10.5
Post-Installation Procedures  11
Keywords  12
Air Barrier Foam Sealant Used in the Rough Opening Gap  Annex A1
Emergency Escape and Rescue Requirements  Annex A2
Minimum Height Requirements for Interior Height of Pan Flashing  Annex A3
Sealants  Annex A4
Window/Door Flashing Types  Appendix X1
Cautions for Installation  Appendix X2
Bibliography/Other Referenced Installation Guides  Appendix X3

Referenced Documents

ASTM Standards
B456 Specification for Electrodeposited Coatings of Copper plus Nickel Plus Chromium and Nickel Plus Chromium
B663 Specification for Silver-Tungsten Carbide Electrical Contact Material
B766 Specification for Electrodeposited Coatings of Cadmium
C717 Terminology of Building Seals and Sealants
C755 Practice for Selection of Vapor Barriers for Thermal Insulation
C794 Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
C834 Specification for Latex Sealants
C920 Specification for Elastomeric Joint Sealants
C1193 Guide for Use of Joint Sealants
C1281 Specification for Preformed Tape Sealants for Glazing Applications
C1299 Guide for Use in Selection of Liquid-Applied Sealants
C1311 Specification for Solvent Release Sealants
C1382 Test Method for Determining Tensile Adhesion Properties of Sealants When Used in
C1397 Practice for Application of Class PB Exterior Insulation and Finish Systems
D779 Test Method for Water Resistance of Paper, Paperboard, and Other Sheet Materials by
the Dry Indicator Method
D1970 Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials, Used as
Steep Roofing Underlayment for Ice Dam Protection
D2822 Specification for Asphalt Roof Cement
E283 Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain
Walls, and Doors Under Specified Pressure Differences Across the Specimen
E331 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain
Walls by Uniform Static Air Pressure Difference
E547 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain
Walls by Cyclic Static Air Pressure Difference
E631 Terminology of Building Constructions
E783 Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows
and Doors
E1105 Test Method for Field Determination of Water Penetration of Installed Exterior
Windows, Skylights, Doors and Curtain Walls by Uniform or Cyclic Static Air Pressure Difference

AAMA Standards
850 Fenestration Sealants Guide Manual

ANSI/AAMA/WDMA Standard
101/I.S.2 Voluntary Specifications for Aluminum, Vinyl (PVC) and Wood Windows and Glass
Doors

AAMA/WDMA Standard
1600/IS7 Voluntary Specifications for Roof Windows and Skylights

ANSI/ASME Standard
A39.1 Standard, Safety Requirements for Window Cleaning

ANSI/EIMA Standard

ANSI/ISDI Standard
102 Insulated Steel Door Systems--Installation Standard

CSA Standards
A440-M90 Windows--A National Standard of Canada

CPSC Standard
16CFR1201 USA Consumer Product Safety Commission, Code of Federal Regulations; Part 1201,

**WDMA Standard**
I.S.4 Industry Standard for Water-Repellent Preservative Treatment for Millwork

**OSHA Standards**
29CFR1926.1101 Asbestos Construction Standard


**Personal Protective Equipment**

**Head Protection**
- Workers must wear hard hats when overhead, falling, or flying hazards exist or when danger of electrical shock is present.
- Inspect hard hats routinely for dents, cracks, or deterioration.
- If a hard hat has taken a heavy blow or electrical shock, you must replace it even when you detect no visible damage.
- Maintain hard hats in good condition; do not drill; clean with strong detergents or solvents; paint; or store them in extreme temperatures.

**Eye and Face Protection**
- Workers must wear safety glasses or face shields for welding, cutting, nailing (including pneumatic), or when working with concrete and/or harmful chemicals.
- Eye and face protectors are designed for particular hazards so be sure to select the type to match the hazard.
- Replace poorly fitting or damaged safety glasses.

**Foot Protection**
- Residential construction workers must wear shoes or boots with slip-resistant and puncture-resistant soles (to prevent slipping and puncture wounds).
- Safety-toed shoes are recommended to prevent crushed toes when working with heavy rolling equipment or falling objects.

**Hand Protection**
- High-quality gloves can prevent injury.
- Gloves should fit snugly.
- Glove gauntlets should be taped for working with fiberglass materials.
- Workers should always wear the right gloves for the job (for example, heavy-duty rubber for concrete work, welding gloves for welding).
**Fall Protection**
- Use a safety harness system for fall protection.
- Use body belts only as positioning devices - not for fall protection.

**OSHA 3142-09R, 2003, Lead in Construction**

**APPLICABILITY TO CONSTRUCTION**

OSHA’s lead in construction standard applies to all construction work where an employee may be exposed to lead. All work related to construction, alteration, or repair, including painting and decorating, is included. Under this standard, construction includes, but is not limited to:

- Demolition or salvage of structures where lead or materials containing lead are present;
- Removal or encapsulation of materials containing lead;
- New construction, alteration, repair, or renovation of structures, substrates, or portions or materials containing lead;
- Installation of products containing lead;
- Lead contamination from emergency cleanup;
- Transportation, disposal, storage, or containment of lead or materials containing lead where construction activities are performed; and
- Maintenance operations associated with these construction activities.

**Employer Responsibilities**

**WORKER PROTECTIONS**

Employers of construction workers are responsible for developing and implementing a worker protection program. At a minimum, the employer’s worker protection program for employees exposed to lead above the PEL should include:

- Hazard determination, including exposure assessment;
- Medical surveillance and provisions for medical removal;
- Job-specific compliance programs;
- Engineering and work practice controls;
- Respiratory protection;
- Protective clothing and equipment;
- Housekeeping;
- Hygiene facilities and practices;
- Signs;
- Employee information and training; and
- Recordkeeping.
Because lead is a cumulative and persistent toxic substance and health effects may result from exposure over prolonged periods, employers must use these precautions where feasible to minimize employee exposure to lead. The employer should, as needed, consult a qualified safety and health professional to develop and implement an effective, site-specific worker protection program. These professionals may work independently or may be associated with an insurance carrier, trade organization, or onsite consultation program.

**ELEMENTS OF A COMPLIANCE PROGRAM**

For each job where employee exposure exceeds the PEL, the employer must establish and implement a written compliance program to reduce employee exposure to the PEL or below. The compliance program must provide for frequent and regular inspections of job sites, materials, and equipment by a competent person. Written programs, which must be reviewed and updated at least every six months, must include:

- A description of each activity in which lead is emitted (such as equipment used, material involved, controls in place, crew size, employee job responsibilities, operating procedures, and maintenance practices);
- The means to be used to achieve compliance and engineering plans and studies used to determine the engineering controls selected where they are required;
- Information on the technology considered to meet the PEL;
- Air monitoring data that document the source of lead emissions;
- A detailed schedule for implementing the program, including copies of documentation (such as purchase orders for equipment, construction contracts);
- A work practice program;
- An administrative control schedule, if applicable; and
- Arrangements made among contractors on multi-contractor sites to inform employees of potential lead exposure.

**Hazard Assessment**

An employer is required to conduct an initial employee exposure assessment of whether employees are exposed to lead at or above the AL based on:

- Any information, observation, or calculation that indicates employee exposure to lead;
- Any previous measurements of airborne lead; and
- Any employee complaints of symptoms attributable to lead exposure.

Objective data and historical measurements of lead may be used to satisfy the standard's initial monitoring requirements.
ASTM C1193 - 09 Standard Guide for Use of Joint Sealants

Significance and Use

This guide provides information and guidelines for consideration by the designer or applicator of a joint seal. It explains the properties and functions of various materials, such as sealant, sealant backing, and primer, among others; and, procedures such as, substrate cleaning and priming, and installation of the components of a sealed joint. It presents guidelines for the use and application of the various materials, design of a sealant joint for a specific application, and environmental conditions and effects that are known to detrimentally affect a sealant joint. The information and guidelines are also useful for those that supply accessories to the sealant industry and for those that install sealants and accessory materials associated with sealant use.

In addition to the design and installation data in this guide, consult the sealant manufacturer about applications for its products and their proper use and installation. Considering the range of properties of commercially available sealants, the variety of joint designs possible, and the many conditions of use, the information contained herein is general in nature.

To assist the user of the guide in locating specific information, a detailed listing of guide numbered sections and their descriptors are included in Appendix X2.

1. Scope

1.1 This guide describes the use of a cold liquid-applied sealant for joint sealing applications. Including joints on buildings and related adjacent areas, such as plazas, decks, and pavements for vehicular or pedestrian use, and types of construction other than highways and airfield pavements and bridges. Information in this guide is primarily applicable to a single and multi-component, cold liquid-applied joint sealant and secondarily to a precured sealant when used with a properly prepared joint opening and substrate surfaces.

1.2 An elastomeric or non-elastomeric sealant described by this guide should meet the requirements of Specification C 834, C 920, or C 1311.

1.3 This guide does not provide information or guidelines for the use of a sealant in a structural sealant glazing application. Guide C 1401 should be consulted for this information. Additionally, it also does not provide information or guidelines for the use of a sealant in an insulating glass unit edge seal used in a structural sealant glazing application. Guide C 1249 should be consulted for this information.

1.4 Practice C 919 should be consulted for information and guidelines for the use of a sealant in an application where an acoustic joint seal is required.

1.5 This guide also does not provide information relative to the numerous types of sealant that are available nor specific generic sealant properties, such as hardness, tack-free time, or curing.
process, among others. Guide C 1299 should be consulted for information on generally accepted comparative values for the characteristics and properties of the more common generic types of liquid-applied sealant.

1.6 The values stated in SI units are to be regarded as the standard. The values given in parenthesis are provided for information only.

1.7 The Committee with jurisdiction for this standard is not aware of any comparable standards published by other organizations.

1.8 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.

1.9 The committee with jurisdiction over this standard is not aware of any comparable standards published by other organizations.

2. Referenced Documents

ASTM Standards
C510 Test Method for Staining and Color Change of Single- or Multicomponent Joint Sealants
C717 Terminology of Building Seals and Sealants
C719 Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)
C792 Test Method for Effects of Heat Aging on Weight Loss, Cracking, and Chalking of Elastomeric Sealants
C794 Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
C834 Specification for Latex Sealants
C919 Practice for Use of Sealants in Acoustical Applications
C920 Specification for Elastomeric Joint Sealants
C1083 Test Method for Water Absorption of Cellular Elastomeric Gaskets and Sealing Materials
C1087 Test Method for Determining Compatibility of Liquid-Applied Sealants with Accessories Used in Structural Glazing Systems
C1135 Test Method for Determining Tensile Adhesion Properties of Structural Sealants
C1247 Test Method for Durability of Sealants Exposed to Continuous Immersion in Liquids
C1248 Test Method for Staining of Porous Substrate by Joint Sealants
C1249 Guide for Secondary Seal for Sealed Insulating Glass Units for Structural Sealant Glazing Applications
C1253 Test Method for Determining the Outgassing Potential of Sealant Backing
C1299 Guide for Use in Selection of Liquid-Applied Sealants
C1311 Specification for Solvent Release Sealants
C1330 Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants
C1382 Test Method for Determining Tensile Adhesion Properties of Sealants When Used in...

C1401 Guide for Structural Sealant Glazing

C1442 Practice for Conducting Tests on Sealants Using Artificial Weathering Apparatus

C1472 Guide for Calculating Movement and Other Effects When Establishing Sealant Joint Width

D2203 Test Method for Staining from Sealants
PART II:  
JOB TASK ANALYSIS OUTLINES
Energy Auditor

Job Task Analysis Content Outline
Job Description: An Energy Auditor is a building analyst that evaluates and analyzes buildings and their energy efficiency, and health and safety aspects by gathering empirical data, conducting tests and using energy modeling software with the goal of identifying areas for savings, reducing energy consumption, improving health and safety, and increasing the lifespan of a building while also improving the quality of life and comfort for building occupants.

## Domains/Tasks

### Domain I: Demonstrating Professional Energy Auditor Conduct

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1</td>
<td>Establish client relations for an energy audit</td>
</tr>
<tr>
<td>Task 2</td>
<td>Represent the program/agency/organization</td>
</tr>
<tr>
<td>Task 3</td>
<td>Maintain professionalism</td>
</tr>
</tbody>
</table>

### Domain II: Collecting Information about the Building for an Energy Audit

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1</td>
<td>Document energy consumption</td>
</tr>
<tr>
<td>Task 2</td>
<td>Document the building history</td>
</tr>
<tr>
<td>Task 3</td>
<td>Conduct a physical/visual inspection</td>
</tr>
<tr>
<td>Task 4</td>
<td>Collect appliance information</td>
</tr>
<tr>
<td>Task 5</td>
<td>Collect electrical base load data</td>
</tr>
<tr>
<td>Task 6</td>
<td>Collect building measurements</td>
</tr>
<tr>
<td>Task 7</td>
<td>Collect health and safety data</td>
</tr>
<tr>
<td>Task 8</td>
<td>Collect mechanical ventilation data</td>
</tr>
<tr>
<td>Task 9</td>
<td>Collect building insulation data (attic, walls and foundations)</td>
</tr>
<tr>
<td>Task 10</td>
<td>Collect attic data</td>
</tr>
<tr>
<td>Task 11</td>
<td>Collect wall data</td>
</tr>
<tr>
<td>Task 12</td>
<td>Collect window data</td>
</tr>
<tr>
<td>Task 13</td>
<td>Collect door data</td>
</tr>
<tr>
<td>Task 14</td>
<td>Collect foundation data</td>
</tr>
<tr>
<td>Task 15</td>
<td>Collect roof data</td>
</tr>
</tbody>
</table>

### Domain III: Testing the Building for an Energy Audit

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1</td>
<td>Preparing for the test(s)</td>
</tr>
<tr>
<td>Task 2</td>
<td>Meter the appliance</td>
</tr>
<tr>
<td>Task 3</td>
<td>Conduct indoor air quality tests</td>
</tr>
<tr>
<td>Task 4</td>
<td>Perform combustion safety and efficiency tests</td>
</tr>
<tr>
<td>Task 5</td>
<td>Perform blower door tests</td>
</tr>
<tr>
<td>Task 6</td>
<td>Perform HVAC distribution tests</td>
</tr>
</tbody>
</table>

### Domain IV: Evaluating Collected Energy Audit Data

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1</td>
<td>Evaluate the health and safety of the building</td>
</tr>
<tr>
<td>Task 2</td>
<td>Evaluate the durability/structural integrity of the building</td>
</tr>
<tr>
<td>Task 3</td>
<td>Evaluate the HVAC system</td>
</tr>
<tr>
<td>Task 4</td>
<td>Evaluate the mechanical ventilation</td>
</tr>
<tr>
<td>Task 5</td>
<td>Evaluate energy use base loads</td>
</tr>
<tr>
<td>Task 6:</td>
<td>Evaluate the foundation</td>
</tr>
<tr>
<td>Task 7:</td>
<td>Evaluate the walls</td>
</tr>
<tr>
<td>Task 8:</td>
<td>Evaluate the attic</td>
</tr>
<tr>
<td>Task 9:</td>
<td>Evaluate the doors</td>
</tr>
<tr>
<td>Task 10:</td>
<td>Evaluate the windows</td>
</tr>
<tr>
<td>Task 11:</td>
<td>Enter the data into energy modeling software</td>
</tr>
<tr>
<td>Task 12:</td>
<td>Determine the work scope</td>
</tr>
</tbody>
</table>
DOMAIN I: Demonstrating Professional Energy Auditor Conduct

Task 1: Establish Client Relations for an Energy Audit

Ability to:
- Conduct client introductions
- Conduct client interviews
- Complete client questionnaires
- Explain the purposes of the visit
- Set the client expectations and responsibilities (pre and post audit)
- Establish the client plan of action
- Engage the client in the actual testing
- Sell the client services and/or packages
- Obtain client signatures on forms (lead forms, etc.)
- Serve as a liaison between the client and the contractors
- Ability to work independently

Knowledge of:
- Building science
- Codes of conduct
- Forms (Lead safety forms, etc)
- Funding sources/financing
- Health and safety issues
- Interviewing techniques
- The program, agency or organization which the Energy Auditor represents

Skill in:
- Communication
- Listening
- Presenting information
- Time management

Task 2: Represent the Program/Agency/Organization

Ability to:
- Interface with crews and subcontractors
- Complete program/agency/organization reports

Knowledge of:
- Construction processes and techniques
- Program reports

Skill in:
- Communication

Task 3: Maintain Professionalism

Ability to:
- Complete continuing education
• Maintain certifications
• Acquire new certifications

Knowledge of:
• Appropriate dress for the situation
• Certification requirements for energy auditors
• Continuing education requirements for energy auditors

DOMAIN II: Collecting Information About the Building for an Energy Audit

Task 1: Document Energy Consumption

Ability to:
• Obtain 12 months of client utility bills
• Obtain annual fuel delivery information (oil, propane, etc.)

Knowledge of:
• How to access utility information
• Utility bill components

Skill in:
• Calculating base loads, the area and volume of building spaces, etc
• Basic Math

Task 2: Document the building history

Ability to:
• Determine the age of the original structure
• Determine the age of any additions or improvements
• Determine if the building has any historical significance

Knowledge of:
• How to access building permit history
• How to access tax files

Task 3: Conduct a physical/visual inspection

Ability to:
• Walk around the exterior of the building
• Locate holes, chimneys, gutters, vent pipes, soffits, fascia, peeling paint, foundation integrity, areas of infiltration and exfiltration, exhaust fan penetrations, accesses, crawlspace, roof vents, land grading, shading, building orientation, anomalies
• Walk around the interior of the building
• Check for pest/vermin infestations, evidence of leaking or water damage, holes, chimneys, vent pipes, peeling paint, foundation integrity, areas of infiltration and exfiltration, exhaust fan penetrations, accesses, crawlspace, roof vents, structural damage
• Identify hidden rooms or spaces
• Determine the exterior façade materials (siding, brick, etc.)
• Identify issues that would interfere with or prevent tests
• Identify hazardous materials in the building
- Identify health and safety issues (clutter, bleach stored next to a furnace, etc.)
- Perform visual inspection of vented combustion appliance venting configuration
- Detect unusual odors
- Photograph and document conditions

Knowledge of:
- General construction
- Codes and standards adopted by the local jurisdiction
- Combustion appliance venting procedures
- Hazardous materials
- Issues that pose a health and/or safety risk
- NFPA 211
- Situations that pose a health and/or safety risk
- Effects of moisture
- Sources of moisture
- What to look for when conducting a physical/visual inspection

Skill in:
- Attention to detail

**Task 4: Collect Appliance Information**

Ability to:
- Collect refrigerator/freezer tag data and documentation
- Collect heating/cooling appliance tag data and documentation
- Identify heating/cooling appliance fuel type
- Collect domestic water heater tag data and documentation
- Collect washer/dryer tag data and documentation
- Collect mechanical ventilation tag data and documentation
- Collect dishwasher tag data and documentation
- Collect shower head flow rates
- Collect dehumidifier tag data and documentation
- Collect stove/oven appliance tag data and documentation
- Identify stoves/ovens appliance fuel type
- Collect unvented space heater tag data and documentation
- Identify other components related to the HVAC appliances (expansion tanks, fill valves, remote compressors, etc.)
- Identify other components related to the domestic water heater appliance (storage tanks, mixing valves, etc.)
- Identify safety features related to the HVAC and domestic water heater appliances

Knowledge of:
- Appliances
- Codes and standards adopted by the local jurisdiction
- Domestic water heater components and operation
- Heating/cooling system operations
• How to read a meter
• How to read and interpret appliance tags
• Mechanical ventilation equipment
• Safety issues associated with domestic water heaters
• Shower head operations and flow rates
• Various appliance fuel types

Skill in:
• Penmanship
• Attention to detail

Task 5: Collect Electrical Base Load Data

Ability to:
• Conduct a lighting audit
• Count the number of people in the house
• Determine if dishwasher is present
• Determine if the domestic water is fuel fired or electric
• Collect client lifestyle information (TV usage, Xboxes, etc.)
• Meter the refrigerator
• Look for additional usage sources (hot tubs, pool pumps, pool heaters, fish ponds, fountains, etc.)

Knowledge of:
• Fuel-fired versus electric domestic water heaters
• How lifestyle affects energy consumption
• How to analyze a utility bill
• How to diagnose high electric/gas usage
• How to read an electric meter
• Refrigerator gasket seal conditions

Skill in:
• Basic math

Task 6: Collect Building Measurements

Ability to:
• Measure walls
• Measure roofs
• Measure windows
• Measure doors
• Measure perimeter
• Measure radiators
• Measure foundation height
• Measure attic venting
• Measure attic spaces
• Measure area and volume of the building envelope

Knowledge of:
- How to calculate the area and volume of the building envelope
- How to identify the pressure boundary
- How to identify the thermal boundary
- How to measure building components (doors, etc.)
- Various building components

**Skill in:**
- Measuring
- Attention to detail
- Basic math

**Task 7: Collect Health and Safety Data**

**Ability to:**
- Locate existing smoke/CO detectors
- Determine age of smoke/CO detectors
- Determine if smoke detectors/CO are hardwired or battery
- Verify clothes dryer is properly vented to exterior
- Verify all exhaust fans are properly vented to exterior
- Identify existence of any possible hazardous materials/conditions
- Identify knob and tube wiring
- Identify moisture issues (standing water, condensation, plumbing leaks, mold, etc.)
- Identify electrical hazards (frayed wiring, open junction boxes, unkempt wires, overloaded circuits, etc.)
- Identify suspect asbestos
- Identify lead based paint hazards
- Identify propane fueled appliances
- Identify unvented combustion appliances
- Identify properly operating back draft damper

**Knowledge of:**
- Proper locations for smoke/CO detectors
- Venting requirements for appliances
- Conditions that signify moisture
- Domestic water heater safety
- Electrical hazards
- Hazardous materials
- Heating system safety
- How to determine if knob and tube wiring is active
- Issues and hazards associated with asbestos
- Issues and hazards associated with lead based paint
- Water heater regulations for manufactured homes
- Rules and regulations pertaining to lead and asbestos
- Smoke/CO detector operations

**Task 8: Collect Mechanical Ventilation Data**
### Ability to:
- Review manufacturer's specifications for exhaust fans
- Determine the volume of the affected space
- Determine the type of control
- Identify the size of the registers
- Determine condition of the ventilation ductwork/piping (pitch, insulation, size, material, elbows, length to run, etc.)
- Calculate volume

### Knowledge of:
- The different controls and motors
- Types of ventilation materials
- Ventilation ductwork
- Ventilation standards and local codes

**Task 9: Identify Building Insulation (attic, walls and foundation)**

### Ability to:
- Identify insulation type
- Identify insulation amount (thickness, etc.)
- Identify insulation condition
- Identify presence and placement of vapor retarder
- Identify location of insulation (exposure, aligned with pressure plane and thermal boundary, etc.)
- Identify areas of insulation opportunities
- Probe
- Work in confined spaces

### Knowledge of:
- Building science
- Insulation effectiveness
- Insulation R-Values
- Insulation placement
- OSHA safety requirements

**Task 10: Collect Attic Data**

### Ability to:
- Identify attic components
- Measure attic/roof cavities
- Measure attic areas
- Measure attic framing
- Determine existing ventilation (soffit, can, ridge, type and size, power ventilators, etc.)
- Identify sources/signs of water damage
- Identify infiltration points
- Identify point(s) of access
- Identify electrical hazards
• Identify pest/vermin infestations
• Determine structural integrity
• Identify whole house fan
• Determine attic uses
• Note the existence of radiant barriers
• Identify existence of baffles
• Use ladders
• Work in confined spaces

Knowledge of:
• Attic components
• Electrical hazards
• General construction terms
• How to calculate the area and volume of building spaces
• Infiltration points
• Safety hazards in an attic (nails, rafters, heat exposure, etc.)
• Signs of water damage
• Signs of pest/vermin infestations
• Thermography
• Types of ladders based on the situation
• Ventilation requirements

Task 11: Collect Wall Data

Ability to:
• Identify wall type (interior, exterior, components)
• Identify framing method
• Measure wall areas
• Identify wall orientation
• Identify cavity depth
• Identify source and signs of any water damage
• Identify infiltration points
• Identify signs of pest/vermin infestation
• Identify orientation using online mapping tools
• Use a compass

Knowledge of:
• General construction
• Building science
• Compass orientations
• Infiltration points
• Typical wall framing and components

Skills in:
• Basic math
• Logical thinking
Task 12: Collect Window Data

Ability to:

- Identify window type (jalousie, awning, single-hung, double hung, etc.)
- Identify window frame type
- Identify window glazing type
- Identify exterior shading
- Identify window operation/leakiness
- Measure window area
- Count number of windows
- Identify window orientation
- Identify general window conditions

Knowledge of:

- Code requirements pertaining to window glazing (walkways, etc.)
- OSHA safety requirements
- SHPO requirements
- Window construction, components and nomenclature

Task 13: Collect Door Data

Ability to:

- Identify door type and swing
- Measure door area
- Count number of doors
- Identify door conditions
- Identify condition of door sweep and weather stripping
- Identify door hardware condition

Knowledge of:

- Door components, hardware and nomenclature
- Door construction
- Door operation and adjustments

Skill in:

- Basic math

Task 14: Collect Foundation Data

Ability to:

- Identify foundation types (crawlspace, basement, or slab)
- Identify foundation materials
- Measure floor areas
- Identify infiltration points
- Measure exposed walls
- Measure thickness of foundations
- Identify sources and signs of moisture
- Identify points of access
- Identify electrical hazards
• Identify signs of pest/vermin infestations
• Determine structural integrity
• Identify special equipment (sump pumps, etc.)
• Measure the crawlspace ventilation
• Record the location of any plumbing pipes
• Work in confined spaces
• Measure

Knowledge of:
• General construction
• Basic Electricity
• Basic Plumbing
• Building science
• Codes and standards adopted by the local jurisdiction
• Crawlspace ventilation requirements
• Foundation construction materials and methods
• OSHA safety requirements
• Potential sources of moisture
• Signs of moisture
• Signs of pests/vermin
• Signs of structural hazards on foundations
• Structures typically found in foundations
• Types of foundations

Skill in:
• Observation

Task 15: Collect Roof Data

Ability to:
• Identify roof conditions
• Identify roof color
• Identify roofing materials (90 lb paper, rubber, etc.)
• Identify condition of parapet walls
• Identify roof penetrations
• Identify roof debris (garbage, old air conditioners, etc.)
• Identify roof ventilation (passive vents)
• Identify roof drainage
• Identify roof pitch
• Measure roof area
• Note flashing condition
• Identify roof access
• Identify roof exposure and orientation
• Identify roof insulation (flat roof with no cavity and with rigid insulation)
• Work at heights
DOMAIN III: Testing the Building for an Energy Audit

**Task 1: Prepare for the Test**

**Ability to:**
- Determine the test(s) to be performed
- Inform the client of the test(s)
- Gather the test tools/equipment
- Prepare the building for testing based upon manufacturer’s test equipment specifications
- Comprehend manufacturer’s specifications
- Use test equipment

**Knowledge of:**
- Building diagnostic testing
- Building science
- Test equipment
- Test protocols

**Skill in:**
- Attention to detail
- Communication

**Task 2: Meter the Appliances**

**Ability to:**
- Inspect appliances for test accessibility
- Plug appliances into the watt hour meter
- Follow the manufacturer’s guidelines for operation of the watt hour meter
- Document findings with pictures/forms
- Read and interpret a watt hour meter

**Knowledge of:**
- Electric appliance metering
- Electric appliance safety

**Task 3: Conduct Indoor Air Quality Tests**

**Ability to:**
- Monitor the ambient CO tests throughout the building
• Record the highest ambient CO reading
• Source the CO
• Determine if the reading exceeds any applicable action levels
• Identify conditions that promote mold growth (high humidity, cold surface condensation, etc.)
• Follow odors to find source of mildew
• Visually identify presence of mold-like substance
• Identify conditions that promote radon infiltration
• Measure the flow of mechanical ventilation
• Document findings with pictures/forms
• Communicate meter results with clients
• Remain calm under stressful situations

Knowledge of:
• ASHRAE maximum allowable CO exposure for living areas
• Carbon monoxide exposure symptoms
• Conditions that promote mold growth
• Conditions that promote radon infiltration
• EPA action levels
• How to measure mechanical ventilation
• NIOSH recommended limit for occupational CO exposure
• OSHA permissible exposure limits

Skill in:
• Remaining dedicated to the cause
• Detecting unusual odors

Task 4: Perform Combustion Safety and Efficiency Tests

Ability to:
• Visually inspect the fuel supply lines
• Test for leakage in the fuel supply pipes
• Verify leaks with bubble solution
• Perform combustion spillage tests
• Perform draft tests (including worst case depressurization, scenario, etc.)
• Measure drafts
• Conduct combustion efficiency tests (CO2, Oxygen, stack temperature, etc.)
• Measure CO in combustion appliances (undiluted)
• Document findings with pictures/forms
• Identify various heating systems
• Work in confined spaces

Knowledge of:
• Back-draft test protocols
• Building science
• Codes and standards adopted by local jurisdiction
- Combustion efficiency tests
- Fuel-line leak testing techniques
- Heating system configurations
- How to conduct draft tests
- How to inspect fuel supply lines
- How to measure CO in appliances
- Nationally recognized combustion safety test protocols (BPI, Energy Outwest, Midwest Best Practices, etc.)
- Various venting methods
- Understanding of what is "worst case": permissible exposures, etc

**Task 5: Perform Blower Door Tests**

**Ability to:**
- Perform pre-blower door interior thermographic scan
- Perform pre-blower door exterior thermographic scan
- Follow manufacturer's specifications for conducting blower door tests
- Perform thermographic scan during the blower door operation
- Perform zone pressure diagnostics (ZPDs)
- Locate points of infiltration/exfiltration
- Document findings with pictures/forms
- Calculate the building tightness limits
- Interpret blower door results

**Knowledge of:**
- Advanced blower door diagnostics
- Blower door testing procedures (pressurization, depressurization, etc.)
- How to assemble and operate a blower door
- How to evaluate zone pressures
- Thermography
- Air sealing limits national standards (BTL, DTL, ACH, BAS, MVG, etc.)

**Skills in:**
- Basic math

**Task 6: Perform HVAC Distribution Tests**

**Ability to:**
- Perform forced air system distribution leakage test
- Verify with building occupants if there is adequate heating and cooling in the building
- Measure room temperatures
- Measure the temperatures of the hydronic radiators
- Perform air flow tests at the registers
- Measure temperature rise across heat exchangers
- Measure pressure drop across the coil
- Inspect hydronic distribution (high, low, valves, etc.)
- Measure hydronic distribution (radiators, fin tube, etc.)
• Perform pressure balancing rooms tests (ducted air systems)
• Document findings with pictures/forms
• Multi-task
• Work in confined spaces

Knowledge of:
• HVAC testing protocols
• Air flow
• How to measure hydronic distribution
• HVAC terminology
• Hydronic heating
• Manufacturer’s specifications for forced air distribution systems
• Distribution system design

Skill in:
• Communication
• Attention to detail

DOMAIN IV: Evaluating Collected Energy Audit Data

Task 1: Evaluate the Health and Safety of the Building

Ability to:
• Review collected data to determine if there is health and safety concern
• Determine if health and safety issues can be addressed through an energy efficiency measure and therefore can fall within energy funding
• Determine the repairs
• Review the economics of the repairs to determine whether to repair or to defer

Knowledge of:
• How to deal with special circumstances (mold, lead, asbestos, etc.)
• Construction repair methods
• Costs associated with repairs
• Energy funding

Skill in:
• Basic math
• Cost estimating

Task 2: Evaluate the Durability/Structural Integrity of the Building

Ability to:
• Review collected data to determine if there is a durability/structural integrity issue
• Determine if the durability/structural integrity issues can be addressed through an energy efficiency measure and therefore can fall within energy funding
• Determine the durability/structural integrity repairs
• Review the economics of the repairs to determine whether to repair or to defer

Knowledge of:
• Codes and standards adopted by local jurisdiction
• Costs associated with structural repairs
• Energy funding
• Structural repair methods

Skill in:
• Basic math
• Cost estimating

Task 3: Evaluate the HVAC System

Ability to:
• Review collected data to determine if there is a HVAC system issue
• Evaluate the HVAC system for health and safety concerns
• Evaluate HVAC sizing for potential replacement or upgrades (post shell retrofit)
• Evaluate the distribution (add trunk lines, radiators, etc. to rooms as needed)
• Evaluate fuel switching options
• Evaluate the need to clean and tune versus replace
• Evaluate the need for and supply of combustion air
• Evaluate the HVAC system for other issues that lead to replacement or upgrades (condition, age, efficiency, etc.)
• Identify duct sealing/insulation and pipe insulation opportunities
• Interpret software output
• Perform load calculations
• Use ACCA software

Knowledge of:
• ACCA manuals
• BTU content of fuels
• Energy funding
• Heating/cooling system operations
• How to size HVAC systems
• HVAC load calculations
• HVAC system repair, replacement or upgrade costs
• Maximum allowable duct leakage
• Safety requirements

Skill in:
• Basic math
• Communication
• Attention to detail

Task 4: Evaluate the Mechanical Ventilation

Ability to:
• Review collected data to determine mechanical ventilation issues
• Compare flow with ventilation specifications
• Compare blower door results against IAQ standards
Assess the need for and placement of additional mechanical ventilation

Assess the make-up air source and whether it needs to be filtered

Determine the mechanical ventilation repairs, replacement and/or addition

Review the economics of the repairs, replacements and/or additions to determine whether to proceed or to defer

Determine the type of controls needed

**Knowledge of:**

- Energy funding
- IAQ standards
- Mechanical ventilation controls
- Types of ventilation
- Ventilation flow
- Ventilation sizing

**Skill in:**

- Basic math

*Task 5: Evaluate Energy Use Base Loads*

**Ability to:**

- Review collected data to determine if replacements or upgrades will reduce energy consumption
- Review energy efficient light bulbs for installation
- Review refrigerator/freezer data for economics of replacement
- Review domestic water heaters for economics of replacement or repair
- Review domestic water heater pipe insulation opportunities
- Review domestic water heater insulation opportunities
- Review water saving opportunities (water saving shower heads, etc.)
- Review domestic water heater thermostat setting

**Knowledge of:**

- Codes and standards adopted by local jurisdiction
- Components of base loads
- Energy funding
- How to calculate base loads
- Pipe insulation

*Task 6: Evaluate the Foundation*

**Ability to:**

- Review collected data to determine foundation issues
- Determine repairs needed
- Review economics of repairs
- Determine proper insulation location (floor or wall)
- Evaluate crawlspace venting needs
- Evaluate box sills insulation needs
- Determine if perimeters need to be insulated
• Identify type of insulation materials to be added
• Calculate if adequate ventilation exists or should be added
• Evaluate the need for vapor barrier

Knowledge of:
• Building science
• Codes and standards adopted by local jurisdiction
• Energy funding
• Foundation construction techniques
• Foundation crawlspace ventilation
• Foundation insulation
• Foundation types
• Foundation vapor barriers

Task 7: Evaluate the Walls

Ability to:
• Review collected data to determine wall issues
• Evaluate repairs needed and structural integrity
• Review the economics of repairs to determine whether to repair or defer
• Determine proper insulation levels
• Identify type of insulation materials to be added
• Determine square footage of area to be insulated
• Ensure pressure plane and thermal boundary align
• Ensure the vapor retarder is appropriately placed

Knowledge of:
• EPA and DOE lead and asbestos standards
• Building science
• Codes and standards adopted by local jurisdiction
• Energy funding
• Insulation types and appropriateness
• Pressure planes and thermal boundaries
• Typical wall structures
• Vapor barriers in walls

Task 8: Evaluate the Attic

Ability to:
• Review collected data to determine attic issues
• Evaluate structural integrity and repairs needed
• Review economic of repairs to determine whether to repair or defer
• Review insulation location
• Review insulation type
• Evaluate whether insulation is appropriate for use
• Ensure pressure plane and thermal boundary align (air sealing)
• Ensure the vapor retarder is appropriately placed
• Evaluate attic ventilation existing and required
• Assess fire hazards (lighting cans, electrical, etc.)
• Evaluate the need for service access

Knowledge of:
• Attic construction and materials
• Attic fire hazards
• Attic types
• Attic ventilation
• Building science
• Codes and standards adopted by local jurisdiction
• Energy funding
• Insulation types and appropriateness
• Pressure planes and thermal boundaries
• Vapor barriers

Task 9: Evaluate the Doors

Ability to:
• Review collected data to determine door issues
• Evaluate repairs needed and structural integrity (can frame support door replacement, etc.)
• Review economics of repairs to determine whether to repair or replace
• Evaluate the condition of storm doors (closers, etc.)

Knowledge of:
• Codes and standards adopted by local jurisdiction
• Door framing structures and processes
• Door types
• Energy funding
• Glass types

Task 10: Evaluate the Windows

Ability to:
• Review collected data to determine window issues
• Evaluate repairs needed and structural integrity
• Review economic of repairs to determine whether to repair or replace
• Evaluate window components and performance

Knowledge of:
• Building science
• Codes and standards adopted by local jurisdiction
• Energy funding
• Window components
• Window glazing
• Window types

Task 11: Enter Data into Energy Modeling Software
Ability to:
- Gather all information and data pertaining to the audit
- Enter the data into energy modeling software
- Analyze the output from the software
- Produce a cost and savings report
- Use a computer

Knowledge of:
- Basic construction terms
- Building science
- Various types of energy modeling software

**Task 12: Determine the Work Scope**

Ability to:
- Determine the health and safety measures
- Determine the building durability measures
- Determine the energy measures based on the SIR
- Provide analysis reports (work order)
- Create reports
- Create work specifications

Knowledge of:
- Building science
- Codes and standards adopted by local jurisdiction
- Construction practices and terms
- Energy modeling software
- Program rules and standards

Skill in:
- Computer usage
Crew Leader

Job Task Analysis Content Outline
Crew Leader Specifications and Content Outline

Job Description: A Crew Leader is responsible for supervising the retrofitting activities specified in the scope of work. He or she is responsible for interacting with the client plus managing personnel and materials on the job site in a safe and effective manner. The Crew Leader is responsible for quality control, testing procedures, documentation, and conducting a final walk through to ensure that all work is completed in a satisfactory manner.

### Domains/Tasks

**Domain I: Develop and/or Review the Work Order**

| Task 1: | Identify and disperse necessary paperwork, (e.g. permits, releases, lead-based paint EPA requirements, historic preservation, etc.) |
| Task 2: | Read, evaluate and discuss with relevant others (auditor, coordinator, program manager, etc.) both audit and homeowner concerns |
| Task 3: | Develop strategy for corrective actions necessary to achieve goals |
| Task 4: | Develop production schedule for crews and subcontractors |

**Domain II: Identify Materials and Staffing Needs**

| Task 1: | Identify skill sets of individuals necessary for job (i.e. crew and contractors) |
| Task 2: | Identify total hours and number of individuals necessary to safely complete the job |
| Task 3: | Identify and obtain tools and materials necessary to complete job |
| Task 4: | Identify Personal Protective Equipment (PPE) necessary for job |

**Domain III: Develop Plan to Execute Work Order on Site**

| Task 1: | Establish rapport and expectations with homeowner |
| Task 2: | Conduct interior and exterior visual home inspection review with crew in order to confirm with client the completion of any prerequisite work |
| Task 3: | Conduct interior and exterior visual home inspection review with crew in order to perform initial job site safety inspection |
| Task 4: | Conduct interior and exterior visual home inspection review with crew in order to develop site-specific safety plan to address any unsafe conditions and possible hazards and inform crew |
| Task 5: | Conduct interior and exterior visual home inspection review with crew in order to document pre-existing conditions (e.g. cracked window, cracked ceiling and walls) |
| Task 6: | Conduct interior and exterior visual home inspection review with crew in order to ensure work areas are accessible and scoped properly |
| Task 7: | Conduct interior and exterior visual home inspection review with crew in order to identify need for job change orders |
| Task 8: | Conduct interior and exterior visual home inspection review with crew in order to adjust work schedule as needed |
| Task 9: | Conduct informative walk through with homeowner to explain what crew will be doing and answer questions and concerns |
Task 10: Conduct informative walk through with homeowner to verify specific homeowner issues (allergies, valuable items, etc.)

Task 11: Conduct informative walk through with homeowner to obtain all necessary sign-offs before work begins

Domain IV: Prepare House to Execute Work Order

Task 1: Protect interior/exterior of house (e.g. with drop cloths, poly, Tyvek booties, pressurization)

Task 2: Set up proper containment, if necessary

Task 3: Test in (e.g. blower door, room to room pressure tests, IR scans, combustion appliances)

Task 4: Revise work order if necessary to reflect current conditions

Domain V: Execute Work Order and Manage Project

Task 1: Monitor safety practices for employees, contractors and job site

Task 2: Communicate with and support crew to ensure job efficiency (e.g. unforeseen circumstances, materials and tools not originally specified)

Task 3: Document work progression and work order changes with photos and notes

Task 4: Maintain quality control

Task 5: Clean up containment zones as necessary

Task 6: Communicate with homeowner as necessary

Task 7: Monitor use of resources (e.g. materials, manpower)

Task 8: Verify that installers track and document material usage

Task 9: Actively mentor crew (e.g. safety, work practices, professionalism)

Task 10: Monitor contractor for job site compliance

Task 11: Conduct daily final walk through to verify that all components of that day’s work scope have been completed and cleaned up appropriately

Domain VI: Job Finalization Activities

Task 1: Walk through to verify that all components of the work scope have been completed

Task 2: Test out (e.g. blower door, IR scans, worst-case draft, combustion testing)

Task 3: Complete clean up

Task 4: Final walk through with homeowner/responsible party

Domain VII: Final Documentation

Task 1: Obtain homeowner/responsible party job-completion sign-off signature

Task 2: Complete all final job documentation (e.g. materials, man hours, photos, time sheets, certified renovator signatures)
Safe Work Practice Skills

Knowledge of:

- U.S. Department of Energy (DOE) program regulations/policy and Environmental Protection Agency (EPA) guidelines for asbestos, lead, mold, and other health hazards
- Material Safety Data Sheets
- Occupational Safety and Health Act (OSHA) standards
- Ladder safety
- Fall protection
- Personal protective equipment
- Respiratory protection
- Safe motor vehicle operation
- Power-operated tools and machinery used on the job site
- Fire prevention
- Permit-required confined spaces
- OSHA 30 Construction Safety Outreach Training
- Other worker-related OSHA standards (e.g. scaffolding, aerial lifts)

Demonstrate the ability to:

- Select and use the appropriate Personal Protection Equipment for a particular task
- Safely use basic hand and power tools
- Use a basic first aid kit to treat common job-site injuries
- Work lead safe
- Identify serious mold conditions
- Assess work area safety hazards
- Use CPR, first aid and AED as required

General Knowledge, Skills and Abilities

Knowledge of:

- Federal, state and local codes, regulations and requirements
- Building science (e.g. heat, moisture, pressure flow; ventilation; thermal and pressure boundary)
- Building techniques and terminology (e.g. critical junctures, flooring systems, crawl spaces, roof framing, mechanical systems)
- Building materials (e.g. dry wall, insulation, house wrap, windows)
- Retrofit techniques (e.g. air tightening, duct sealing, insulation)
- What certifications are required for each job task
- Material inventory and availability
- Material performance
- All activities being performed by crews and contractors on site
## Ability to:

- Read and interpret the audit report
- Integrate information from multiple sources
- Estimate time required to complete each component of the work scope
- Sequence required tasks
- Assess crew member and contractor capabilities
- Estimate job and personnel requirements based on conditions
- Estimate amount of materials needed to complete job
- Communicate at an appropriate level (e.g. technical to layman level, language barriers)
- Relate well with others in tactful and professional manner
- Conduct oneself in an ethical manner
- Identify materials and methods appropriate for the current job
- Job coach and relay retrofit techniques appropriately
- Install appropriate containment zones with best practices
- Perform and record all diagnostic procedures (e.g. blower door, manometer, duct blower, combustion analyzer)
- Assess skills and recommend additional formal training for crew and contractors
- Manage multiple operations and/or sites
- Use construction math (e.g. measure and compute area, volume, circumference)
Retrofit Installer/Technician

Job Task Analysis Content Outline
Retrofit Installer/Technician Specifications and Content Outline

Job Description: A Retrofit Installer/Technician installs energy-efficiency measures to single family or 2-4 unit-homes using a variety of building science best practices to improve safety, comfort, durability, indoor air quality, and energy efficiency.

**Domains/ Tasks**

**Domain I: Maintain Safety**
- **Task 1:** Follow work rules of jurisdiction having authority
- **Task 2:** Handle materials/equipment according to manufacturer specifications
- **Task 3:** Handle tools according to manufacturer specifications

**Domain II: Prepare for the Job (before arriving to job site)**
- **Task 1:** Attend training
- **Task 2:** Gather materials and supplies
- **Task 3:** Gather tools

**Domain III: Prepare and Maintain Tools and Materials On-site**
- **Task 1:** Set up tools
- **Task 2:** Set up materials

**Domain IV: Prepare and Maintain Job Site**
- **Task 1:** Attend job site safety meeting
- **Task 2:** Implement safety protocol (rigging, ventilation, blocking)
- **Task 3:** Use protective barriers (drop cloths)
- **Task 4:** Report preexisting conditions (that are not in scope)
- **Task 5:** Protect exterior environment

**Domain V: Implement Work Scope**
- **Task 1:** Locate specific work areas
- **Task 2:** Verify access to work areas
- **Task 3a:** Install air sealing measures
- **Task 3b:** Install loose fill insulation
- **Task 3c:** Install or patch moisture barriers
- **Task 3d:** Install ventilation
- **Task 3e:** Install mechanical systems
- **Task 3f:** Commission equipment/systems
- **Task 3g:** Confirm and ensure combustion safety
- **Task 3h:** Install dense pack insulation
- **Task 3i:** Install windows and doors
- **Task 3j:** Install electrical (rough-in, fans)
- **Task 3k:** Install plumbing
- **Task 3l:** Install roofing and flashing
- **Task 4:** Clean as you go (organize)
- **Task 5:** Address deviations from work scope

**Domain VI: Wrap Up**
| Task 1: | Pick up tools and materials |
| Task 2: | Clean up and close out |
| Task 3: | Participate in crew debriefing (after action review, post construction job review) |
DOMAIN I: Maintain Safety

Task 1: Follow Work Rules of Jurisdiction having Authority

Ability to:
- Read or hear safety documents
- Implement safety procedures
- Report safety concerns and violations
- Wear safety equipment
- Attend safety meetings/trainings
- Request safety training
- Install safety guards

Knowledge of:
- Installation procedures
- Manufacturer's specifications
- OSHA
- Safety systems

Task 2: Handle Materials/Equipment According to Manufacturer Specifications

Ability to:
- Read or hear manufacturers specifications/MSDS
- Store and maintain materials/equipment according to manufacturers specs/MSDS

Knowledge of:
- Manufacturer's specifications

Task 3: Handle Tools According to Manufacturer Specifications

Ability to:
- Read or hear manufacturers specifications
- Store and maintain tools according to manufacturers specs

Knowledge of:
- Manufacturer's specifications

DOMAIN II: Prepare for the Job (before arriving at job site)

Task 1: Attend Training

Ability to:
- Participate in training
- Identify strengths and weaknesses of yourself
- Modify installation practice based on training
- Sign in to training

Knowledge of:
- Existing practice
- Safety procedures
Task 2: Gather Materials and Supplies

Ability to:
- Review materials list
- Compare materials to work scope
- Verify and protect materials condition
- Organize materials (put in truck, pull from truck, etc.)
- Report missing or deficient material

Knowledge of:
- Compatibility
- Material handling
- Materials
- Materials limits
- MSDS
- Physical limits of materials
- Work scope

Task 3: Gather Tools

Ability to:
- Review tool list
- Compare tools to work scope
- Verify and protect tools condition
- Load/unload tools
- Report missing or deficient tool
- Modify tools for specific job requirements (change bits/blades)

Knowledge of:
- Work scope
- Manufacturer's specifications
- Materials handling
- Lifting safety
- Normal tool operations

DOMAIN III: Prepare and Maintain Tools and Materials On-site

Task 1: Set Up Tools

Ability to:
- Unload tools from vehicle
- Connect attachments
- Plug in tools
- Verify operational status
- Perform routine maintenance
- Report deficiencies

Knowledge of:
• Carrying techniques
• Double insulated tools
• Electrical safety
• GFCI
• Lifting techniques
• Manufacturer's specifications
• Normal operations
• Tool recognition
• Work scope

Task 2: Set Up Materials

Ability to:
• Unload materials from vehicle
• Organize materials
• Confirm materials match work specification
• Maintain integrity of materials
• Report deficiencies

Knowledge of:
• Job site
• Lifting techniques
• Materials
• Materials limits and characteristics
• Work scope

DOMA IV: Prepare and Maintain Job Site

Task 1: Attend Job Site Safety Meeting

Ability to:
• Attend
• Participate
• Sign in

Task 2: Implement Safety Protocol (rigging, ventilation, blocking)

Ability to:
• Set up safety masking and drop cloths
• Set up ventilation in confined spaces
• Set up task lighting
• Hook up to fall protection
• Set up ladders, scaffolding, climbing equipment
• Put on personal protective equipment
• Lock out/tag out
• Inspect work area for hazards
• Report work area hazards
### Knowledge of:
- Combustibles
- Confined spaces
- Electrical safety
- EPA lead safety
- Equipment operation
- Fall protection
- Fit test
- Hazard recognition
- Lanyards
- Local codes
- Manufacturer’s specifications
- Materials
- OSHA
- Personal protection
- Safety protocols
- Ventilation systems and requirements
- Work scope

**Task 3: Use Protective Barriers (drop cloths)**

### Ability to:
- Move furniture (confirm permission)
- Cover furniture/storage areas/clothes in closets
- Protect furniture
- Protect floors
- Follow safe practices, including lead safe practices (EPA)
- Place drop cloths, tack mats
- Use designated facilities (eating, bathroom, smoke break)

### Knowledge of:
- Adjacent characteristics
- Electronics
- EPA lead safety
- Flooring characteristics
- Lifting techniques
- Materials characteristics
- Safe practices
- Work scope

**Task 4: Report Preexisting Conditions (that are not in scope)**

### Ability to:
- Identify preexisting conditions (aesthetic/structural)
- Report preexisting conditions
- Report difficult to access places (excessive customer stuff, customer behavior issues)
Knowledge of:
• General construction
• Work scope

Task 5: Protect Exterior Environment

Ability to:
• Control dust and debris created by equipment from construction activities
• Protect landscaping (covering, using limiting stakes)
• Check for oil leaks
• Report mishaps (spills, cracks)

Knowledge of:
• Work scope
• Retaining walls
• General landscape knowledge
• Containment requirements

DOMAIN V: Implement Work Scope

Task 1: Locate Specific Work Areas

Ability to:
• Review the work scope
• Walk the job site
• Find mechanicals

Knowledge of:
• General construction
• General mechanical knowledge
• Job site specifics
• Work scope

Task 2: Verify Access to Work Areas

Ability to:
• Confirm approval for start of work
• Work with crew chief to get access to areas (moving personal belongings, getting into crawl space, etc.)
• Remove obstructions for start of work

Knowledge of:
• Work scope
• General construction
• Job site
• Lifting safety

Task 3a: Install Air Sealing Measures

Ability to:
• Identify leaks and bypasses
• Select materials
• Look for fire code violations
• Block large openings

• Hand seal gaps and cracks
• Check the seal is complete

**Knowledge of:**
• Clearances
• Fire code
• Framing components
• How to operate a blower
• How to utilize tracer gas
• Leak site
• Material capability (e.g. temperature limits, width of span of sealant)
• Material capability (e.g. temperature limits, width of span of sealant)
• Material durability
• Material strength
• Penetrations
• Tolerances

**Task 3b: Install Loose Fill Insulation**

**Ability to:**
• Confirm air sealing is complete
• Confirm exhaust fans ducted to outside and insulated
• Confirm HVAC duct work is intact, sealed, supported, and insulated
• Confirm clearance to combustibles
• Confirm clearance to electrical
• Install baffles, blocking, platforms, and insulation dams
• Install vertical insulation (6-sided boxes, knee walls)
• Install horizontal insulation
• Compare material use to coverage required (bags consumed)

**Knowledge of:**
• Clearance
• Combustibles
• Component analysis
• Coverage charts
• Depth markers
• Duct requirements
• General carpentry
• How to draw a floor plan
• How to operate a blower
• Insulation requirements
- Manufacturer's specifications for installations
- Materials
- Rigid board types
- R-Values
- Termination requirements
- Thermal barriers

**Task 3c: Install or Patch Moisture Barriers**

**Ability to:**
- Confirm positive drainage, or notify of stop work items
- Remove all organic/inorganic materials
- Install moisture barrier and seal joints and seams
- Verify flashing is installed
- Identify and locate moisture sources
- Report bulk moisture concerns

**Knowledge of:**
- Flashing locations
- Grading issues
- Gravity
- Installation standards
- Materials
- Moisture problems
- Moisture symptoms
- Roof slope changes
- Where to look for moisture

**Task 3d: Install Ventilation**

**Ability to:**
- Uncrate equipment
- Remove old equipment
- Confirm electrical and plumbing requirements are in place
- Cut openings in building
- Install venting system and vent terminations
- Install, air seal, and insulate ducting system
- Confirm installation is complete

**Knowledge of:**
- Building science
- Equipment disconnects
- Equipment requirements
- Equipment shut offs
- Framing
- How to conduct duct leak tests
- How to read duct diagrams
- Manufacturer's specifications
- Penetration locations
- Protection of materials
- Smoke tests of joints
- Use of power tools
- Utility knife safety

**Task 3e: Install Mechanical Systems**

**Ability to:**
- Uncrate and verify equipment
- Remove old equipment
- Confirm electrical requirements are in place
- Confirm plumbing requirements are in place
- Confirm fuel requirements are in place
- Cut openings in building
- Install equipment and renewable systems
- Install or reconnect return and distribution systems (hot water, steam, hydronic, forced air, etc.)
- Provide return path
- Install, air seal, and insulate ducting system
- Confirm installation is complete
- Connect or install combustion vent system exhaust

**Knowledge of:**
- Cavity protection
- Circuit testers
- Circulating pumps
- Code requirements
- Connectors
- Disconnects
- EPA safety
- Equipment requirements
- Flow
- Flow through system
- Framing
- General carpentry
- How to lock joints
- Insulation
- Leakage of ducts
- Manufacturer’s specifications
- Mastics
- Penetration locations
- Piping
- Protection of materials
- Sheet metal
- Shut offs
- Slope
- System attachments
- Temperature of conditioned space
- Use of power tools
- Utility knife safety

**3f: Commission Equipment/Systems**

**Ability to:**
- Verify all connections
- Verify operation
- Adjust to OEM specifications
- Report results

**Knowledge of:**
- Design specifications
- Gas pressure tests
- Manufacturer’s specifications
- OEM specifications
- Types of materials for appliances

**Task 3g: Confirm and Ensure Combustion Safety**

**Ability to:**
- Check for safety issues -- ambient (gas leaks, CO, toxins)
- Set up house for natural conditions
- Run combustion equipment in proper sequence
- Check for draft under worst case
- Report findings

**Knowledge of:**
- Combustion safety testing
- Draft testing
- Natural conditions
- Safety protocols
- Use of tools
- Venting systems
- Worse case set-up

**Task 3h: Install Dense Pack Insulation**

**Ability to:**
- Fine tune machine for application (density)
- Locate drill points
- Confirm building component integrity
- Get access to all building cavities, locate all horizontal blocks
- Check for hazards
- Fill first cavity and confirm density stops air leakage
- Readjust machine
- Fill all cavities
- Compare material use to coverage required (bags consumed)
- Plug hole, patch weather barrier, put siding back, seal openings, caulk joints

Knowledge of:
- Basic math skills
- Blower door testing
- Building structures
- Dense pack procedures
- Drill points
- Equipment
- Framing
- General carpentry
- Hazards
- How to probe
- Limitations of components
- Materials
- Smoke testing
- Strength of components
- Testing procedures
- Velocity of insulation material during installation

Task 3i: Install Windows and Doors

Ability to:
- Remove old windows and doors
- Check and install waterproofing, flashing
- Install windows and doors
- Install air barrier and ensure drainage
- Verify air tightness and drainage

Knowledge of:
- 1/16 inch accuracy
- Air
- Basic math skills
- Building techniques
- Building codes
- Building practices
- Building science
- Drainage planes
- EPA lead safety
- Fasteners
• Flashing techniques
• General carpentry
• Manufacturer’s specifications
• Materials
• Pressure
• Quality installations
• Vapor barriers
• Window and door types

**Task 3j: Install Electrical (rough-in, fans)**

**Ability to:**
• Resolve hazards
• Provide power to new equipment/appliance
• Install or repair circuit
• Install or repair lighting
• Install or repair controls
• Seal penetrations and replace insulation
• Install systems, including photovoltaic

**Knowledge of:**
• Appliance requirements
• Building codes
• Building science
• Circuitry
• Clearances
• Efficiency
• Fire code
• Local codes
• Manufacturer’s specifications
• Materials
• NEC
• Potential damage
• Trade-specific knowledge
• Wiring

**Task 3k: Install Plumbing**

**Ability to:**
• Remove old equipment
• Resolve hazards
• Provide hookups
• Install or repair fixtures
• Install equipment including renewable systems
• Seal penetrations and replace insulation
• Check for draft
• Install simple efficiency measures (low-flow fixtures, pipe wrap insulation)
• Install advanced efficiency measures (hot water loop, on demand water heaters, on demand remote, solar)

Knowledge of:
• Advanced plumbing knowledge
• Asbestos
• Basic carpentry
• BPI combustion safety
• Brazing
• Building codes
• Building science
• Combustible clearances
• Domestic water heaters
• Drainage
• Electrical knowledge
• Fuel gas code
• Gas fitting
• Gas fitting code
• Gaskets
• Grading
• Interior finish
• Local hazards
• Manufacturer's specifications
• Materials
• Pipe fitting
• Pipe insulation
• Piping
• Smooth wrench surfaces
• Tapes
• Temperature requirements
• Venting
• Vermin hazards

Task 3i: Install Roofing and Flashing

Ability to:
• Identify leak sources
• Repair leak source
• Remove roofing system
• Install roofing system
• Insulate roof deck
• Install attic ventilation
• Flash new penetrations
Knowledge of:
- Building science
- Carpentry
- Clearances
- Debris control
- Drainage
- Drainage plane
- Fall protection
- Fasteners
- Flashing
- General carpentry
- Gravity
- Live load
- Local building codes
- Manufacturer's specifications
- Materials
- Math skills
- Product installations
- Roofing systems
- Tools

**Task 4: Clean as You Go (organize)**

Ability to:
- Return tools to central area
- Pick up material drops
- Return belongings
- Clean work area

Knowledge of:
- Disposable materials
- Dust containment
- EPA lead safety
- Materials MSDS
- Safety knowledge
- Safety requirements
- Solvents
- Tool inventory
- Tool safety

**Task 5: Address Deviations from Work Scope**

Ability to:
- Identify deviation
- Report deviation
- Request direction for modified work scope
• Implement modified work scope

**Knowledge of:**
• Work scope

### DOMAIN VI: Wrap Up

#### Task 1: Pick Up Tools and Materials

**Ability to:**
• Inventory tools and materials used
• Clean tools and materials
• Store tools and materials
• Report lost or broken items

**Knowledge of:**
• Basic math skills
• Manufacturer's specifications
• Materials
• Solvents
• Tool safety
• Value of materials

#### Task 2: Clean Up and Close Out

**Ability to:**
• Break down barriers
• Pick up protective barriers
• Contain hazardous materials
• Contain and dispose of materials and waste
• Dust, vacuum, mop, scrub, rake
• Restore occupant belongings
• Participate in final walk through inside and outside, including restoring mechanical systems
• Report to crew chief for final inspection

**Knowledge of:**
• Disposal procedures
• EPA lead safety
• Hazardous materials
• Local codes
• Local facilities
• MSDS
• Safe lifting practices
• Safety procedures
• Work scope

#### Task 3: Participate in Crew Debriefing (after action review, post construction job review)
### Ability to:
- Attend meeting
- Report deficient knowledge (more instruction for installer)
- Report what went well and what went wrong
- Discuss homeowner concerns, complaints, and complements
- Offer additional safety suggestions

### Knowledge of:
- Safety procedures
- Work scope
Quality Control Inspector

Job Task Analysis Content Outline
Quality Control Inspector Specifications and Content Outline

Job Description: A Quality Control Inspector is an evaluator who verifies the work performed against the work plan, specifications and standards, performs building diagnostics, records/reports findings and concerns, and specifies corrective actions; by conducting a methodological audit/inspection of the building, performing safety and diagnostic tests, and by observing the retrofit work; in order to ensure the completion, appropriateness and quality of the work providing for the safety, comfort, and energy savings of the building occupants.

<table>
<thead>
<tr>
<th>Domains/Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain I: Conducting Quality Checks - In-Process Visual/Sensory Inspections</td>
</tr>
<tr>
<td>Task 1: Verify worker compliance with safety rules</td>
</tr>
<tr>
<td>Task 2: Assure worker professionalism</td>
</tr>
<tr>
<td>Task 3: Address work problems</td>
</tr>
<tr>
<td>Task 4: Evaluate client satisfaction regarding the in-process work</td>
</tr>
<tr>
<td>Domain II: Conducting Quality Checks - Post-Work Visual/Sensory Inspection</td>
</tr>
<tr>
<td>Task 1: Review client file and the work scope</td>
</tr>
<tr>
<td>Task 2: Perform an exterior and interior visual/sensory inspection</td>
</tr>
<tr>
<td>Task 3: Evaluate client satisfaction</td>
</tr>
<tr>
<td>Task 4: Determine pass/fail of the work</td>
</tr>
<tr>
<td>Domain III: Conducting Quality Checks - Post-Work Diagnostic Inspections</td>
</tr>
<tr>
<td>Task 1: Conduct health and safety tests</td>
</tr>
<tr>
<td>Task 2: Conduct diagnostic tests</td>
</tr>
<tr>
<td>Task 3: Identify work problems</td>
</tr>
<tr>
<td>Domain IV: Ensuring Worker Professionalism</td>
</tr>
<tr>
<td>Task 1: Perform spot checks</td>
</tr>
<tr>
<td>Task 2: Provide feedback regarding professionalism</td>
</tr>
<tr>
<td>Domain V: Ensuring Program or Project Compliance</td>
</tr>
<tr>
<td>Task 1: Maintain professional credentials</td>
</tr>
<tr>
<td>Task 2: Confirm the allocation of public/private funds</td>
</tr>
<tr>
<td>Task 3: Evaluate installed measures against the field guide, SWS and state/local codes</td>
</tr>
<tr>
<td>Task 4: Close out the project</td>
</tr>
<tr>
<td>Task 5: Maintain files and records</td>
</tr>
</tbody>
</table>
DOMAIN I: Conducting Quality Checks - In-Process Visual/Sensory Inspections

Task 1: Verify Worker Compliance with Safety Rules

Ability to:
- Walk around the job site
- Observe the workers
- Observe the site conditions
- Interview the crew chief
- Work in confined spaces

Knowledge of:
- Basic construction knowledge
- Codes and standards adopted by the local jurisdiction
- Federal Regulations (OSHA, EPA, etc.)
- First aid
- Interview techniques

Skill in:
- Communication
- Observation techniques

Task 2: Assure Worker Professionalism

Ability to:
- Conduct client interviews
- Evaluate the job site (trash, cleanliness, etc.)
- Verify that workers are familiar with their employers' code of conduct
- Observe the behavior of the workers

Knowledge of:
- Awareness of the employers' requirements
- Knowledge of positive reinforcement techniques

Skill in:
- Communication
- Observation
- Remaining tactful

Task 3: Address Work Problems

Ability to:
- Review the work against the work plan
- Observe worker skills
- Check materials being installed (proper materials and quality of materials)
- Observe sequencing of the components being installed
- Verify the condition and capacity of the equipment
- Determine need to conduct diagnostic tests
- Conduct diagnostic tests
- Document process issues and missed opportunities for change orders
- Revise work orders
- Redirect retrofit work
- Discuss issues with the crew chief
- Demonstrate proper methods to installers
- Discuss missed opportunities with the auditor

**Knowledge of:**
- Basic building science
- Codes and standards adopted by the local jurisdiction
- Building materials
- Construction tools and use
- Construction work practices
- Documentation procedures
- Installation methods
- Standards and specifications
- Test protocols
- Various diagnostic tests

**Skill In:**
- Communication
- Being diplomatic
- Observation
- Training

**Task 4: Evaluate Client Satisfaction Regarding the In-Process Work**

**Ability to:**
- Interview the client
- Observe client behavior (is the client uncomfortable, are the workers affecting the client, etc.)
- Document findings
- Communicate findings to the crew chief or other responsible parties

**Knowledge of:**
- Interview techniques

**Skill in:**
- Communication
- Observation
DOMAIN II: Conducting Quality Checks - Post-Work Visual/Sensory Inspections

Task 1: Review Client File and the Work Scope

Ability to:
- Review the audit
- Review the work order
- Review the invoices or job completion report
- Review diagnostic test results provided by installers
- Interpret diagnostic test results
- Interpret invoices
- Interpret work order
- Reconcile audit to work order to invoice

Knowledge of:
- Program or project requirements
- Diagnostic procedures
- The audit process
- Job costing

Task 2: Perform an Exterior and Interior Visual/Sensory Inspection

Ability to:
- Perform exterior and interior walk around
- Compare observations of exterior/interior to the client file (work order, audit, invoices, etc).
- Verify installed components
- Note any anomalies or potentially missed opportunities or audit discrepancies
- Identify damage done by contractors/workers
- Document non-conformance or exceptional work with camera
- Identify additional building specific diagnostic tests

Knowledge of:
- Audit processes
- Basic building science
- Building materials
- Codes and standards adopted by the local jurisdiction
- Construction work practices
- Installation methods
- Standards and specifications
- Test protocols
- Various diagnostic tests

Skill in:
- Analytical thinking
- Basic math
Basic tool use
Observation
Organization

Task 3: Evaluate Client Satisfaction

Ability to:
- Conduct client specific interview (behavior changes, client education, comfort, satisfaction)
- Conduct program specific interview (worker performance, process, scheduling, value, opportunities for improvement)
- Observe client behavior (thermostat settings, attire, manual weather stripping, windows open, etc)
- Document client feedback
- Take corrective actions (as necessary)

Knowledge of:
- Client education
- Installed components

Skill in:
- Communication
- Listening
- Mediation
- Observation
- Remaining tactful

Task 4: Determine Pass/Fail of the Work

Ability to:
- Review results of visual/sensory inspection
- Review results of diagnostic tests
- Make a pass/fail determination
- Obtain client sign-off if passed
- Report inspection approval if passed
- Identify work problems if failed
- Generate a punch list if failed

Knowledge of:
- Basic building science
- Diagnostic thresholds
- Codes and standards adopted by the local jurisdiction
- Standards and specifications

Skill in:
- Making decisions
- Being accurate
- Analytical thinking
- Attention to detail
• Remaining tactful

DOMAIN III: Conducting Quality Checks - Post-Work Diagnostic Inspections

Task 1: Conduct Health and Safety Tests

Ability to:
• Perform combustion tests (heating systems, domestic water heater, ovens, stoves, fireplaces, etc.)
• Perform ventilation system tests
• Conduct moisture evaluations
• Conduct electrical safety tests

Knowledge of:
• Codes and standards adopted by the local jurisdiction
• Combustion safety protocols
• First aid
• Heating systems
• Moisture issues
• Safety issues

Skill in:
• Analytical thinking

Task 2: Conduct Diagnostic Tests

Ability to:
• Perform blower door tests
• Perform pressure pan test
• Conduct zone tests
• Perform fan flow tests
• Perform infrared scans
• Perform duct leakage tests
• Perform electric circuit tests
• Perform refrigerant tests
• Conduct appliance tests
• Conduct domestic water heater temperature tests
• Record the results of all tests

Knowledge of:
• Basic building science
• Diagnostic testing protocols
• Manufacturers' specifications
• Program requirements

Skill in:
• Attention to detail

Task 3: Identify Work Problems
Ability to:
- Review the results of all tests
- Compare results against field guide notes
- Compare results against pre-test data
- Compare results against work plan projections
- Identify missed opportunities
- Determine deficiencies
- Target deficiencies for corrective actions
- Generate a punch list
- Interpret data
- Make decisions
- Read a flowchart

Knowledge of:
- Basic building science
- Field guides
- Codes and standards adopted by the local jurisdiction
- Standards and specifications
- Testing protocols

Skill in:
- Analytical thinking
- Communication

DOMAIN IV: Ensuring Worker Professionalism

Task 1: Perform Spot Checks

Ability to:
- Visit in-process job sites
- Conduct random sampling of job site documents
- Conduct random sampling of worker credentials
- Observe the workers
- Interview the client
- Interview trade workers on the job
- Interview others at the job site
- Ability to observe without interfering

Knowledge of:
- Credentialing requirements for workers
- Professional behavior and code of conduct
- Program and agency guidelines
- Required documentation
Skill in:
- Attention to detail
- Communication
- Listening
- Observation
- Remaining tactful

**Task 2: Provide Feedback Regarding Professionalism**

**Ability to:**
- Document incidences of lack of professionalism
- Document positive incidences of professionalism
- Communicate with crew chief or appropriate party regarding professionalism incidences
- Assure client of corrective measures
- Assist in training workers

**Knowledge of:**
- Professional behavior and code of conduct
- Required documentation

**Skill in:**
- Remaining impartial
- Communication

**DOMAIN V: Ensuring Program or Project Compliance**

**Task 1: Maintain Professional Credentials**

**Ability to:**
- Continue education and training
- Maintain professional licenses and/or certifications
- Maintain memberships in professional organizations (REPA, ACI, Energy Outwest, NARI, etc.)
- Participate in industry activities (JTAs, etc.)

**Knowledge of:**
- Licensure and certification requirements

**Task 2: Confirm the Allocation of Public/Private Funds**

**Ability to:**
- Review work orders
- Flag instances where work completed doesn't match funding requirements
- Guard against cost overruns
- Report disallowed costs

**Knowledge of:**
- Scopes of work
- Allowable activities under funding sources
• Maximum allowable caps on funding sources

Skill in:
• Analytical thinking
• Attention to detail

**Task 3: Evaluate Installed Measures Against the Field Guide, Standard Work Specifications and State/Local Codes**

Ability to:
• Compare work completed with the accepted practices
• Identify work that does not meet accepted practices
• Determine if problem is a material problem or a work problem
• Suggest program change recommendations
• Recommend education for auditors and installers
• Ability to aggregate information
• Ability to identify gaps in training
• Ability to write a report

Knowledge of:
• Basic building science
• Codes and standards adopted by the local jurisdiction
• Industry standards
• Program requirements
• Training curriculum

Skill in:
• Analytical thinking
• Remaining tactful

**Task 4: Close out the Project**

Ability to:
• Ensure all punch-list items have been completed
• Assemble all required documentation paperwork ( certificates, photos, etc. )
• Confirm all required signatures were obtained
• Prepare completion reports (checklists, required agency reports, etc.)
• Submit authorization for payments/reimbursements/invoices

Knowledge of:
• Agency/company processes
• Program requirements
• Required paperwork
• Required signatures

Skill in:
• Organization
• Report writing

**Task 5: Maintain Files and Records**

Ability to:
• Maintain job logs and notes in the files
• Maintain photos in the files
• Maintain information on any anomalies on the job
• Maintain information on any ongoing complaints
• Maintain documentation from program monitoring (federal, utility, etc.)

Knowledge of:
• Legal responsibilities
• Program requirements
• Recordkeeping best practices

Skill in:
• Attention to detail
• Organization
Workforce Guidelines for Home Energy Upgrades

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