

Retrofitting North Dakota



**Standard Work Specifications
and Field Guide**

for

Single-Family Homes

created by

North Dakota Department of Commerce

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2.0100.1b

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

Durable and wrist-protecting gloves will be worn that can withstand work activity

Objective(s):

Minimize skin contact with contaminants

Protect hands from sharp objects



Recognize potential risks



Wear appropriate hand protection

2.0100.1c

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

If the risk of airborne contaminants cannot be prevented, proper respiratory protection will be provided and worn (e.g., N-95 or equivalent face mask)

When applying low pressure 2-component spray polyurethane foam, air purifying masks with an organic vapor cartridge and P-100 particulate filter will be used

When applying high-pressure SPF insulation, supplied air respirators (SARs) will be used

Consult SDSs for respiratory protection requirements

Objective(s):

Minimize exposure to airborne contaminants (e.g., insulation materials, mold spores, feces, bacteria, chemicals)



Workers need to properly protect their airways when retrofitting



Retrofits can have multiple different respiratory protection requirements

2.0100.1d

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

An electrical safety assessment will be performed

All electric tools will be protected by ground-fault circuit interrupters (GFCI)

Three-wire type extension cords will be used with portable electric tools

Worn or frayed electrical cords will not be used

Water sources (e.g., condensate pans) and electrical sources will be kept separate

Metal ladders will be avoided

Special precautions will be taken if knob and tube wiring is present

Aluminum foil products will be kept away from live wires For arc flash hazards, ND State Electrical Code will be consulted

Objective(s):

Avoid electrical shock and arc flash hazards



Unsafe

Inspect house for unsafe electrical situations



Attics and crawl spaces should be inspected closely for electrical safety before work begins

2.0100.1e

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

All homes will have a carbon monoxide alarm

Ambient CO will be monitored during combustion testing and testing will be discontinued if ambient CO level inside the home or work space exceeds 35 parts per million (ppm)

Objective(s):

Protect worker and occupant health

Tools:

1. CO meter



Unsafe

STOP WORK if CO levels are higher than 35ppm!!



Best Practice

Alarms should be mounted near sleeping areas--such as the one marked in red



Best Practice

Install carbon monoxide alarms

2.0105.1b; 2.0201.2c; 2.0301.2a; 3.1501.1f

Paraphrased from ND State Building Code: An approved CO alarm will be installed outside of each separate sleeping area in the immediate vicinity of the bedrooms in dwelling units within which fuel-fired appliances are installed and in dwelling units that have attached garages. CO detectors will comply with UL 2075. Single-station CO alarms will comply with UL 2034 and will be installed in accordance with this code and the manufacturer's installation instructions. Per WPN 14-01, full compliance with ASHRAE 62.2.2013 and NFPA 720 is required.

2.0100.1f

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

SDSs and OSHA regulations will be consulted for protective clothing and equipment

Eye protection will always be worn (e.g., safety glasses, goggles if not using full-face respirator)

Objective(s):

Protect worker from skin contact with contaminants

Minimize spread of contaminants



Workers should be aware of work required and dress appropriately



Ensure workers have proper protective equipment for work environment

2.0105.2d

2.0100.1g

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

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

Objective(s):

Prevent build-up of toxic or flammable contaminants

Provide adequate access and egress points

Prevent electrical shock



Locate all access and egress points of confined spaces before entering

2.0100.1j

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

Appropriate PPE will be used (e.g., knee pads, bump caps, additional padding)

Proper equipment will be used for work

Proper lifting techniques will be used

Objective(s):

Prevent injuries from awkward postures, repetitive motions, and improper lifting



Workers will take precautions to protect themselves on the job site



Hard hats, knee pads, bump caps, and team lifts help to prevent injury

2.0100.1m

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

Appropriate ventilation, hydration, rest breaks, and cooling equipment will be provided

911 will be dialed when necessary

Objective(s):

Prevent heat stroke, heat stress, and cold stress related injuries



Attics and crawl spaces can be dangerous work places in the heat



Keep workers comfortable with hydration and cool vests

2.0100.1p

Desired Outcome:

Windows operable and weather tight; improved energy efficiency performance of fenestration

Specification(s):

Presence of lead-based paint in pre-1978 homes will be assumed unless testing confirms otherwise

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) will be complied with, to be superseded by any subsequent final rulemaking or any more stringent state or federal standards

Objective(s):

Protect worker and occupant from potential lead hazards

Tools:

1. Note: Mask must be worn during testing
2. LeadCheck test kit
3. Utility knife
4. Camera



Best Practice

In homes built before 1978, test paint before beginning renovation

EPA RRP certification required to conduct Lead Paint assessment.

3.1201.2a; 3.1201.3a; 3.1202.1a; 3.1202.2a; 3.1203.1a; 3.1203.2a

3.1201.1a

2.01001.1d - Lead paint assessment



1
Clean tools and sample site to prevent contamination



2
Cut sample site at an angle to expose all older paint layers



3
Break capsules and shake to mix reagents. Swab sample site for 30 seconds



4
Check swab for reaction



5
Red indicates lead positive. White is lead negative.



6
If negative, verify validity of test with provided calibration card



7
Lead in calibration card should test positive and turn red



8
Record test results to maintain documentation

2.0103.1c

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

Raw fuel leaks will be monitored for before entering building spaces

If leaks are found, testing will be discontinued and condition reported to occupant immediately

Objective(s):

Protect worker and occupant health

Tools:

1. Gas sniffer
2. Bubble solution



Before

Fuel leaks need to be repaired by appropriate professional



After

Notify occupant of any leaks

2.0201.1b

2.0103.2b

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

When replacing existing thermostats, identify and dispose of any mercury containing thermostats in accordance with Environmental Protection Agency (EPA) guidance

Objective(s):

Protect workers and occupants from mercury exposure



Unsafe

Mercury thermostats should be replaced and disposed of properly



Unsafe

Do NOT dispose of mercury thermostats in the trash--find local recycling

Paraphrased from 40 CFR 273.14: A universal waste mercury-containing thermostat or container containing only universal waste mercury-containing thermostats should be labeled or marked clearly with any of the following phrases: "Universal Waste-Mercury Thermostat(s)," "Waste Mercury Thermostat(s)," or "Used Mercury Thermostat(s)." **Contact thermostat-recycle.org or earth911.org for recycling options.

2.0107.2a

Desired Outcome:

Site properly prepared for upgrade

Specification(s):

Fuel leaks will be repaired and inspected in accordance with the 2012 IRC

Objective(s):

Ensure site is safe and ready for upgrade

Tools:

1. Combustion gas detector
2. Testing solution



Unsafe

Fuel leaks need to be repaired



Safe

Repairs need to be tested and verified to no longer leak

Paraphrased from ND State Building Code: Leakage will be located using an *approved* combustible gas detector, a noncorrosive leak detection fluid or an equivalent nonflammable solution.

Matches, candles, open flames or other methods that could provide a source of ignition cannot be used. Where leakage or other defects are located, the affected portion of the *pipng system* will be repaired or replaced and retested.

2.0201.1b

2.0107.3a

Desired Outcome:

Clean, safe, and easily accessible crawl space created

Specification(s):

Under-floor grade will be removed of all vegetation and organic material that may puncture ground cover

Debris that can cause injury or puncture ground covers will be removed from the crawl space as needed

Objective(s):

Minimize punctures in ground liner

Minimize habitat for pests (Integrated Pest Management—IPM) and contaminant sources

Tools:

1. Rake
2. PPE



Before

Crawl spaces with trash and overgrowth need to be made clean and safe.



After

Rake up and clear away trash and overgrowth.

2.0201.1a

Desired Outcome:

Accurate information about appliance safe operation is gathered

Specification(s):

Emergency problems (e.g., gas leak, ambient CO levels that exceed 35 ppm) will be communicated clearly and immediately to the customer and appropriate solutions will be suggested

Determine if combustion and dilution air is adequate for proper combustion and venting of all equipment within the CAZ

Examine appliance for signs of damage, misuse, improper repairs, and lack of maintenance

Objective(s):

Ensure system does not have fatal problems

Ensure combustion appliance has adequate combustion and dilution air



Before

Unsafe combustion appliances indicate need for repair or replacement



After

In cases of replacement, ensure new appliance is safe and sized properly

2.0201.1c

Desired Outcome:

Accurate information about appliance safe operation is gathered

Specification(s):

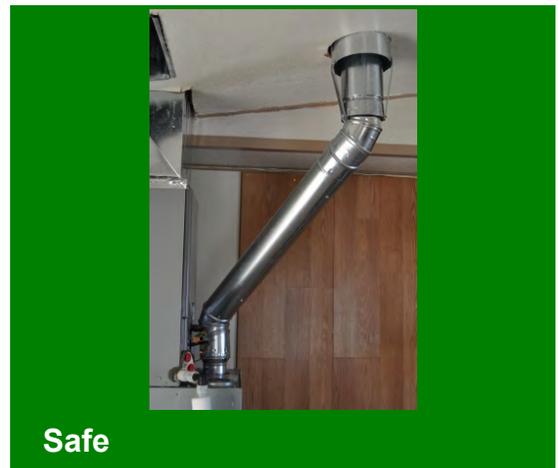
Combustion venting systems will be inspected for damage, leaks, disconnections, inadequate slope, and other safety hazards

Objective(s):

Determine if a draft regulator is present and working and if vent system is in good condition and installed properly



If ventilation system puts occupants at risk, it needs immediate attention



Properly vented appliances make a house healthier and more efficient

2.0201.1c - Venting



Determine if a draft regulator is installed and working



Inspect ventilation systems for damage



Inspect ventilation systems for disconnected pipes



Inspect ventilation systems for inadequate slope



Inspect for missing draft diverter

2.0201.1e - Depressurization test

Desired Outcome:

Accurate information about appliance safe operation is gathered

Specification(s):

Depressurization test will include exhaust fans, interior door closure, or duct leakage, or a combination thereof.

Objective(s):

Measure combined effect of mechanical system fans on combustion zone

Tools:

1. Manometer



Best Practice
Exhaust fans on, Check interior doors, Air handler on?

2.0201.1e - Depressurization test



1 Place manometer reference hose to exterior of house



2 Attach test hose to be used in the interior of the house



3 Place test hose by combustion appliance



4 Close all interior doors unless there is an exhaust fan or return duct existing



5 Turn on interior exhaust fans, including any clothes dryers



6 Take a reading with the air handler on and with the air handler off and determine which is worst case



7 Take a reading with the CAZ door closed and open and determine which is worst case

2.0201.1f - Spillage test

Desired Outcome:

Accurate information about appliance safe operation is gathered

Specification(s):

If a combustion appliance spillage exceeds two minutes on a warm vent or 5 minutes on a cold vent during pressure testing, specify measures to mitigate

Objective(s):

Detect excessive spillage of combustion gasses

Tools:

1. Smoke pencil
2. Timer



Unsafe

Test natural draft furnace or water heater for spillage in excess of 2 minutes for warm vents and 5 minutes for cold vents



Best Practice

Test all sides of natural draft flues since draft may be uneven

2.0201.1g

Desired Outcome:

Accurate information about appliance safe operation is gathered

Specification(s):

CO will be tested for in undiluted flue gases of combustion appliances

If CO levels exceed levels in the chart below, service will be provided to reduce CO to below these levels (unless CO measurement is within manufacturer specifications)

If the outlet of the exhaust is accessible, include a CO test on all sealed-combustion, direct vent, and power-vented appliances (without atmospheric chimneys)

Objective(s):

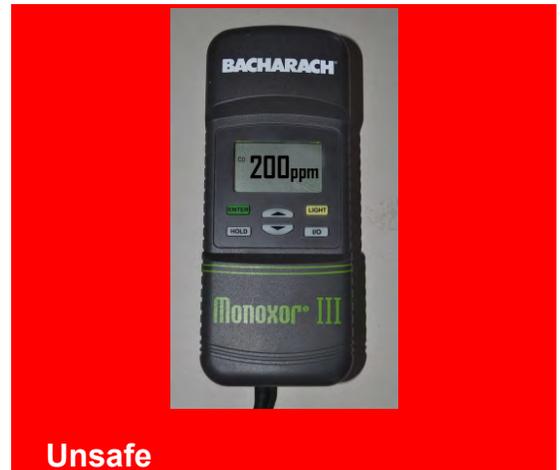
Measure CO and report excessive levels

Tools:

1. Combustion analyzer with probe

CO Thresholds for Fossil-Fuel Fired Combustion Appliances

Appliance	Threshold Limit
Central Furnace (all categories)	400 ppm air free
Boiler	400 ppm air free
Floor Furnace	400 ppm air free
Gravity Furnace	400 ppm air free
Wall Furnace (BIV)	200 ppm air free
Wall Furnace (Direct Vent)	400 ppm air free
Vented Room Heater	200 ppm air free
Unvented Room Heater	200 ppm air free
Water Heater	200 ppm air free
Oven/Broiler	225 ppm as measured
Clothes Dryer	400 ppm air free
Refrigerator	25 ppm as measured
Gas Log (gas fireplace)	25 ppm as measured in vent
Gas Log (installed in wood burning fireplace)	400 ppm air free in firebox



Unsafe

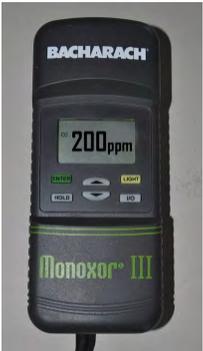
CO levels cannot exceed levels in the chart below, unless to manufacturer specs



Best Practice

Test CO levels in undiluted flue gases and exhaust outlets, when accessible

2.0201.1g - Carbon monoxide (CO) test in appliance vent



CO levels cannot exceed 200ppm, or 400ppm air-free CO



Test undiluted flue gases in induced-draft furnaces



Test undiluted flue gases in natural draft furnaces



Test undiluted flue gases in natural draft water heaters.



Test accessible exhaust outlets for direct-vent appliances



Test accessible exhaust outlets for power-vented appliances

2.0201.1i

Desired Outcome:

Accurate information about appliance safe operation is gathered

Specification(s):

At the conclusion of each work day in which envelope or duct sealing measures have been performed, depressurization and spillage testing will be performed

Objective(s):

Ensure work completed in home has not adversely affected the operation of combustion appliances

Tools:

1. Manometer
2. Smoke pencil
3. Timer



Conduct spillage and depressurization testing at the end of the work day

2.0201.2a

Desired Outcome:

Buildup of dangerous combustion byproducts in the living space prevented

Specification(s):

Where applicable, combustion air will only be provided from the exterior of the structure

Objective(s):

Prevent combustion byproducts from entering the house

For homes with one permanent opening, see ND State Building Code: a minimum free area of

1 in² per 3,000 Btu/h (734 mm²/kW) of total input rating of all appliances

For homes with two permanent vertical duct openings, see ND State Building Code: a

minimum free area of 1 in² per 4,000 Btu/h (550 mm²/kW) of total input rating of all

appliances

For homes with two permanent horizontal duct openings, see ND State Building Code: a
minimum free area of 1 in² per 2,000 Btu/h (1,100 mm²/kW) of total input rating of all
appliances

2.0201.2d

Desired Outcome:

Buildup of dangerous combustion byproducts in the living space prevented

Specification(s):

Gas ovens will be tested for CO

A clean and tune will be conducted if measured CO in the undiluted flue gases of the oven vent at steady state exceeds 225 ppm as measured

Objective(s):

Ensure clean burn of gas ovens

Tools:

1. Combustion analyzer with probe



If air-free CO reading exceeds 800ppm, order a clean and tune



Test gas oven for carbon monoxide using a combustion gas analyzer

2.0201.2e

Desired Outcome:

Buildup of dangerous combustion byproducts in the living space prevented

Specification(s):

Specify clean and tune if the flame has any discoloration, flame impingement, or an irregular pattern or if burners are visibly dirty, corroded, or bent

Objective(s):

Ensure clean burn and operation of gas range burners



Discoloration is a clear sign that a gas range needs a clean and tune



A properly operating gas range burner should have an even blue flame

2.0201.2f

Desired Outcome:

Buildup of dangerous combustion byproducts in the living space prevented

Specification(s):

If the solid fuel burning appliance is the primary heat source and has signs of structural failure replace solid fuel burning appliance with UL-listed and EPA - certified appliances if the existing appliance is not UL-listed

Objective(s):

Ensure safe operations of solid fuel burning appliances



Unsafe solid fuel burning appliances should be replaced



New appliances should be UL-listed and EPA-certified

2.0203.2a

Desired Outcome:

Flue gasses successfully removed from the house

Specification(s):

If spillage in a combustion appliance with a warm vent exceeds two minutes during pressure testing, specify measures to mitigate. If spillage in a combustion appliance with a cold vent exceeds five minutes during pressure testing, specify measures to mitigate.

Objective(s):

Ensure appliance is not spilling longer than two minutes

Tools:

1. Smoke pencil



Orphaned water heaters have oversized flues after a furnace is removed



Spillage should not exceed 2 minutes, if present

2.0203.2c

2.0203.2b

Desired Outcome:

Flue gasses successfully removed from the house

Specification(s):

A chimney liner will be installed in accordance with the 2012 IRC or applicable NFPA standard

Objective(s):

Allow water heater to vent properly

Prevent damage to the chimney



Before
Unlined masonry chimney



After
Flue liner with rain cap

Tools:

1. hammer drill
2. disposable brushes
3. tin snips
4. 5/16" nut driver
5. pulling cone
6. rope
7. caulking gun
8. tape measure
9. 4 1/2" angle grinder with metal cutoff wheel

Materials:

1. Flexible chimney liner
2. Rain cap
3. Top plate
4. Elbows
5. Tees (if required to connect multiple appliances)
6. Refractory cement
7. Bricks
8. Mortar

Connect chimney liner to appliance in accordance with applicable codes.

2.0203.2b - Flue gas removal (chimney liner or approved methods)



1 Measure from the bottom termination to the chimney crown. Add one foot to the measurement and cut the liner to length



2 Pull chimney liner into position (from top or bottom, whichever is easier) with a rope and pulling cone



3 Measure and mark the flexible chimney liner at 4 inches above the chimney



4 Cut the flexible chimney liner to length



5 Install top plate over opening and attach it to the liner



6 Fasten the rain cap to the chimney liner



7 Seal around penetrations in chimney with refractory (furnace) cement



8 Connect appliance vent to the chimney liner



9 Use refractory (furnace) cement to seal metal water heater or furnace vents to the masonry chimney

2.0301.1b

Desired Outcome:

Properly installed smoke alarms

Specification(s):

Smoke detectors will be installed within 15 feet of all bedrooms and a minimum of one on each floor

Objective(s):

Ensure proper installation



Best Practice

All homes should have UL-217 rated smoke alarms

2.0301.1b - Smoke alarm (battery operated)



Ceiling mounted smoke alarms can be battery-operated



Wall mounted smoke alarms must be mounted within 12 inches of the ceiling

2.0301.2b

Desired Outcome:

Properly installed CO alarms or monitors

Specification(s):

Battery operated CO detection or warning equipment will be installed in accordance with ASHRAE 62.2 2016 and manufacturer specifications as required by the authority having jurisdiction

Objective(s):

Ensure proper installation



All houses should have carbon monoxide monitors installed near sleeping areas



Battery operated CO alarms should be UL-2075 or UL-2034 compliant

Per WPN, full compliance with ASHRAE 62.2.2016 and NFPA 720 is required.

2.0403.1b

Desired Outcome:

Durable, effective ground moisture barrier provides long-lasting access and minimizes ground vapor

Specification(s):

A ground moisture barrier that covers 100% of the exposed crawl space floor will be installed

Objective(s):

Reduce ground moisture entering the crawl space

Materials:

1. Plastic sheeting (at least 6 mil)
2. Furring strips
3. Fasteners



Uncovered crawl space floors can cause moisture damage



Ground moisture barrier to cover 100% of floor is installed last

2.0403.1d; 2.0403.2b; 2.0403.2d; 2.0403.2e; 2.0403.2f

2.0403.1c

Desired Outcome:

Durable, effective ground moisture barrier provides long-lasting access and minimizes ground vapor

Specification(s):

A ground moisture barrier with a rating of no less than 6 mil will be used

A ground moisture barrier will be used that meets tear and puncture resistance standard ASTM E1745

Homeowner will be advised that all plastic is biodegradable and will have a life span much shorter than the home (5 years), and it will need replacing to remain effective

Objective(s):

Ensure crawl space is accessible for service and maintenance without damaging the integrity of the ground moisture barrier

Materials:

1. Plastic sheeting (at least 6 mil)
2. Furring strips
3. Fasteners



Barrier must be at least 6 mil, able to withstand puncture and last 10 yrs

The higher a material's perm rating, the more vapor can pass through said material. Drywall typically has a perm rating of approximately 50. Vapor retarders must be 6 mil.

2.0403.2c

2.0403.1e

Desired Outcome:

Durable, effective ground moisture barrier provides long-lasting access and minimizes ground vapor

Specification(s):

Ground moisture barrier will be fastened to ground with durable fasteners or ballast(s) and extend a minimum of 6" up the foundation wall

Objective(s):

Prevent movement of the ground moisture barrier

Tools:

1. Stapler
2. Drill

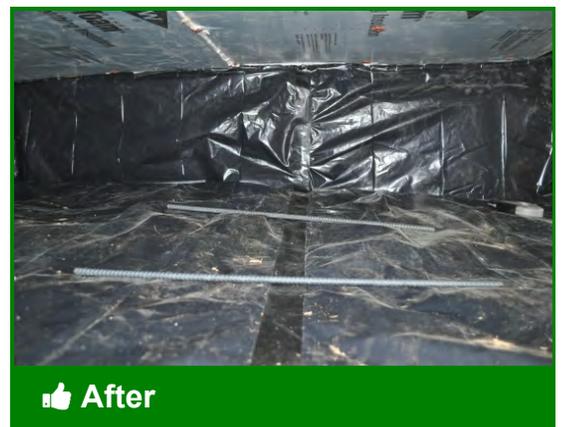
Materials:

1. Plastic sheeting (at least 6 mil)
2. Furring strips
3. Fasteners



Before

Fastening of moisture barrier is required and must last at least 10 years



After

Ground moisture barrier should extend up the wall and be held in place

2.0601.1c

Desired Outcome:

Live unsafe wiring identified and brought to local codes

Specification(s):

Live knob and tube will not be covered or surrounded; required by the ND State Electrical Code or authority having jurisdiction

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

Objective(s):

Ensure occupant safety

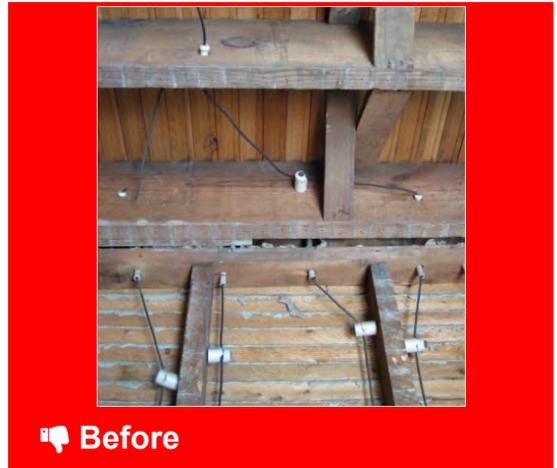
Preserve the integrity and safety of the house

Tools:

1. Drill
2. Tape measure
3. Non-contact wire tester

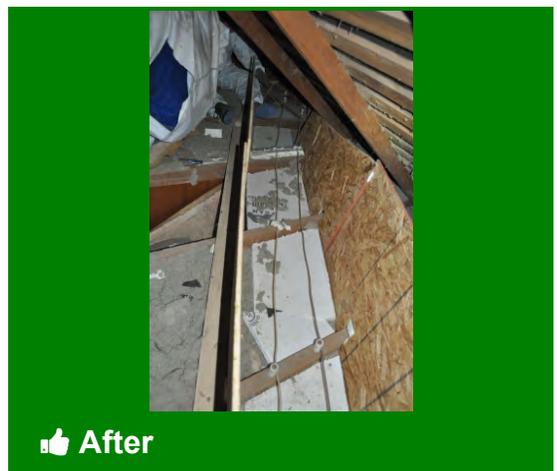
Materials:

1. Plywood
2. Drywall
3. Fasteners



Before

Live knob & tube wiring may get hot and should not be insulated over



After

Dams should be installed to hold back loose fill insulation

NEC guidelines and local jurisdictions are very particular on the treatment of knob & tube wiring.

Check your local codes.

2.0601.1a; 2.0601.1b; 2.0601.1d; 4.1001.2a; 4.1001.2b; 4.1001.2c

3.1001.1d

Desired Outcome:

Penetrations and chases sealed to prevent air leakage and moisture movement between the attic and conditioned space

Specification(s):

Only non-combustible sealant will be used in contact with chimneys, vents, and flues

Local codes will be referenced

Objective(s):

Prevent a fire hazard

Tools:

- 1. Drill/screwdriver
- 2. Caulk gun
- 3. Metal snips

Materials:

- 1. High-temperature caulking
- 2. 26-gauge steel sheeting



👎 Before

Gaps around combustion exhaust flues need to be sealed



👍 After

Sealed penetrations and chases should utilize high-temperature materials

Minimum of a 3" Clearance to all Combustibles

3.1402.1c

3.1001.1d - High temperature application



Prepare work area by removing any insulation and debris



Use high-temperature caulking (600F min)



Apply first ring of caulking to match shape of opening



Apply second ring of caulking to size and shape of rigid material



Fasten rigid material (26-gauge steel) and apply additional caulking



Fasten rigid material to cover penetration and seal against flue with caulk

3.1001.2a

Desired Outcome:

Chase capped to prevent air leakage and moisture movement between the attic and conditioned space

Specification(s):

An inspection will be conducted for mold, water leaks, and water damage before sealing a chase

Repairs will be completed before work begins

Objective(s):

Repair moisture-related issues



🗨️ Before

Investigate under insulation in chases to verify they are undamaged



Before

Water damage in chase due to hole to the outside

Tools:

1. flashlight
2. headlamp
3. hammer
4. prybar
5. circular saw
6. reciprocating saw
7. borescope
8. mirror

Removing the batt over this chimney chase provided access to see a large hole and water damage in the chimney wall.

3.1001.2a - Pre-inspection



1
Locate and expose chases to prepare for inspection and capping/sealing



2
Clear away insulation and debris to allow inspection



3
Carefully investigate areas with high potential for water leaks

3.1001.2b

Desired Outcome:

Chase capped to prevent air leakage and moisture movement between the attic and conditioned space

Specification(s):

Entire opening will be spanned with rigid material

Material will be cut to fit and fastened as required

Objective(s):

Reduce opening to what can be sealed with sealant

Tools:

- 1. Drill/screwdriver
- 2. Caulk gun

Materials:

- 1. XPS
- 2. Drywall
- 3. Caulk
- 4. Sheet metal
- 5. OSB or plywood



Unsealed standard chases covered with drywall can be leakage points



The air barrier is maintained by capping chases with rigid material

3.1001.2c

Desired Outcome:

Chase capped to prevent air leakage and moisture movement between the attic and conditioned space

Specification(s):

Material will be used that can be exposed to the interior of the house and meet the flame and smoke spread indexes as required in ND State Building Code

Objective(s):

Prevent a fire hazard

Tools:

1. Drywall saw
2. Tape measure
3. Caulk gun
4. Drill

Materials:

1. Drywall
2. XPS
3. Fire-block sealant
4. Fasteners



Paneled drop soffits typically are more combustible than plain drywall



When sealing on attic side, drywall and XPS are viable materials

EPS or bead-board are not acceptable materials.

3.1003.6c

3.1001.2d

Desired Outcome:

Chase capped to prevent air leakage and moisture movement between the attic and conditioned space

Specification(s):

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)

Objective(s):

Ensure seal stays in place and does not sag

Tools:

1. Drill
2. Saw
3. Tape measure

Materials:

1. Lumber
2. Drywall
3. Fasteners



Spans greater than 24 inches require additional bracing before capping



Support should prevent cap from sagging or moving

3.1001.3c; 3.1003.1c; 3.1003.2c; 3.1003.3c; 3.1003.4c

3.1001.2e

Desired Outcome:

Chase capped to prevent air leakage and moisture movement between the attic and conditioned space

Specification(s):

Continuous seal will be installed around seams, cracks, joints, edges, penetrations, and connections

Objective(s):

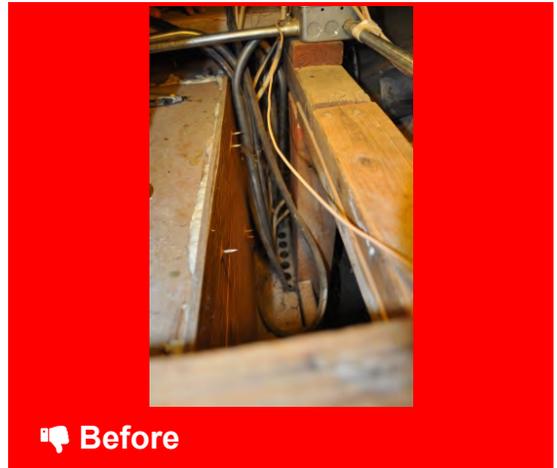
Provide airtight, durable seal that does not move, bend, or sag

Tools:

1. Spray foam gun
2. Caulk gun

Materials:

1. Spray foam
2. Caulk



Before

Chases need to be capped and sealed to prevent leakage



After

Chase is sealed along all cracks, gaps, and penetrations

Always wear protective gloves when working with sealants.

3.1001.2f; 3.1003.6b; 3.1003.6d; 3.1003.6c

3.1001.3b

Desired Outcome:

Continuous air barrier prevents air leakage and moisture movement between the attic and conditioned space

Specification(s):

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

Wall below openings will be dense packed

OR

Wall below openings will be bridged and sealed with spray polyurethane foam (SPF)

Sealants will be used that prevent visible air movement using chemical smoke at 50 pascals of pressure difference

Objective(s):

Prevent air leakage from wall cavity to attic

Tools:

1. Utility knife
2. Saw
3. Insulation machine
4. Caulk gun
5. Spray foam gun

Materials:

1. Drywall
2. XPS
3. Spray foam
4. Caulk
5. Fasteners
6. Dense packable insulation
7. Lumber



Wall cavities are open to attic



Whatever option chosen, test for visible air movement with smoke pencil

3.1001.3b - Sealing methods



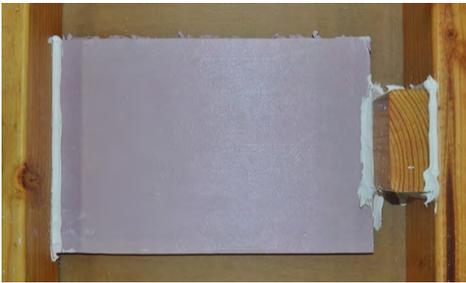
Option 1: Dense pack cavities through wood cap fastened in place



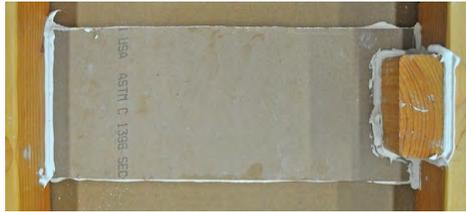
Option 2: Bridge cavities with spray foam



Option 3, Step 1: Apply sealant around opening and on surrounding framing



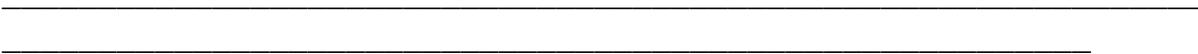
Option 3, Step 2, Option A: Cap with XPS and seal exposed joints



Option 3, Step 2, Option B: Cap with drywall and seal exposed joints

3.1001.3e; 3.1003.1b; 3.1003.1d; 3.1003.1e; 3.1003.2d

3.1003.2e; 3.1003.3b; 3.1003.3d; 3.1003.3e; 3.1003.4d; 3.1003.4e



3.1003.6d

Desired Outcome:

Dropped soffits sealed to prevent air leakage and moisture movement between the attic and conditioned space

Specification(s):

Each stud bay will be spanned with rigid material will be cut to fit and fastened as required

OR

Backing at each stud bay will be provided and will be sealed

OR

Side of stud bays will be sealed with rigid material from bottom of soffit to top-plate

OR

A sealed rigid barrier will be installed at all transitions

Objective(s):

Prevent air leakage from wall to soffit

Reduce opening to what can be sealed with sealant

Ensure soffit is outside of the thermal boundary

Tools:

1. Tape measure
2. Utility knife
3. Saw
4. Insulation machine
5. Drill
6. Caulk gun
7. Spray foam gun

Materials:

1. XPS
2. Drywall
3. Plywood
4. Lumber
5. Fasteners
6. Caulk
7. Spray foam
8. Dense packable insulation
9. Poly-wrapped insulation



🗨 Before

Wall cavities are open to attic and heat transfer due to dropped soffit



👍 After

Wall cavities capped and air-sealed in one of a variety of options

3.1003.6d - Option 2: leave soffit outside (seal at bottom or side)



Clear work area of insulation and debris



Option 1: Span each stud bay with rigid material at level of soffit



Option 2: Backing used to fill bays and sealed with spray foam



Option 3: Stud bay will faced with rigid material, fastened and sealed

3.1201.1d

Desired Outcome:

Windows operable and weather tight; improved energy efficiency performance of fenestration

Specification(s):

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

Objective(s):

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

Tools:

1. Saw
2. Drill
3. Pry bar
4. Sander
5. Caulk gun

Materials:

1. Lumber or metal sill
2. Caulk
3. Fasteners
4. Flashing



Before

Rot in and under a window sill is often a sign of a bigger problem



After

Once repaired, this window is less leaky and better supported

3.1201.1d - Replacement sills



Remove sill to determine full extent of rot and necessary repairs



Once rotted materials are cut away, determine sizing of new materials



Cut new materials flush to surrounding surfaces and pitch toward exterior



For exterior repairs, replace flashing



Set new sill, then replace and prime trim

3.1201.3b

Desired Outcome:

Doors operable and weather tight

Specification(s):

Door will be adjusted to properly fit the jamb and allow for ease of operation (e.g., hinge replacement, re-plane door, door strike adjustment)

Objective(s):

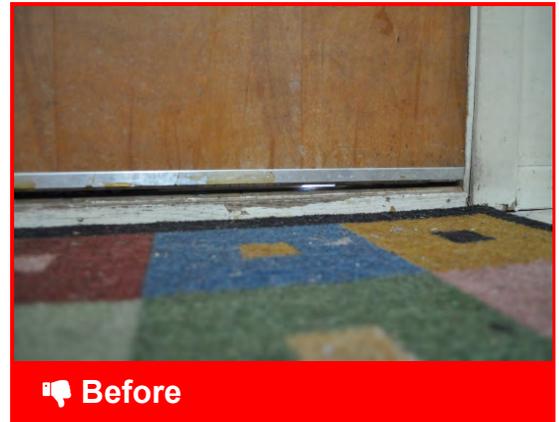
Ensure proper operation of the door

Tools:

1. Screwdriver
2. Planer

Materials:

1. Shims



Daylight visible around door can indicate it does not hang true and leaks



With proper adjustment, doors should hang true and minimize leakage

3.1201.3c; 3.1201.3d; 3.1501.1d

3.1202.1b

Desired Outcome:

Glass complete and intact; improved energy efficiency performance of fenestration

Specification(s):

Putty and push points will be removed

Broken or cracked glass will be removed

Objective(s):

Safely remove old glass

Tools:

1. Putty knife
2. Chisel
3. Utility knife
4. Shop vacuum
5. Tape measure

Materials:

1. Tape



Broken glass with failed repairs needs to be replaced



Large pieces of glass have been removed but sash still needs preparation

Always wear heavy work gloves when working with glass. See also 2.0100.1b for Hand

Protection.

3.1202.2b

3.1202.1c

Desired Outcome:

Glass complete and intact; improved energy efficiency performance of fenestration

Specification(s):

Opening will be cleaned

Objective(s):

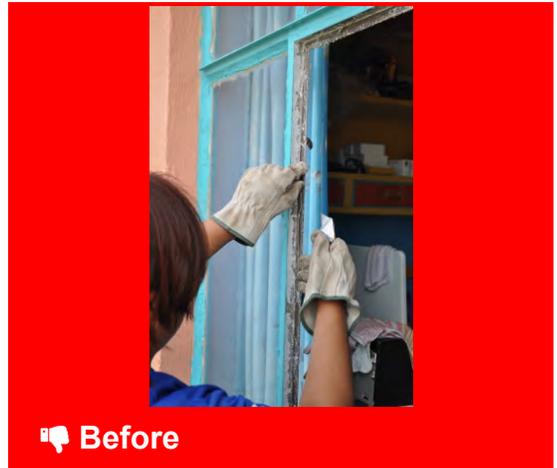
Prepare opening for new glass

Tools:

1. Chisel
2. Utility knife

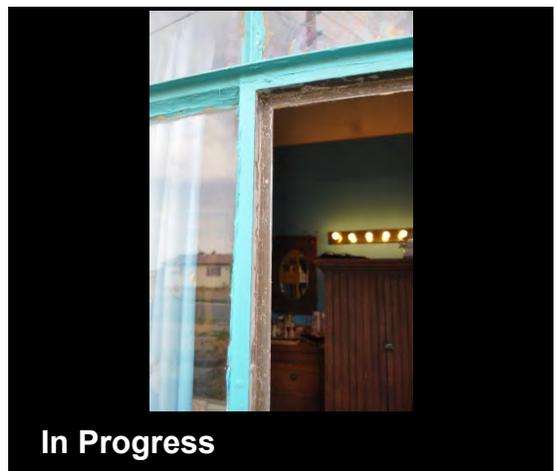
Materials:

1. Sand paper
2. Cleaning solution
3. Rags



Before

Remove all debris from sash either by sand paper, knife, or chisel



In Progress

Mount new glass onto a clean surface

3.1202.2c

3.1202.1d

Desired Outcome:

Glass complete and intact; improved energy efficiency performance of fenestration

Specification(s):

Glass will be sized 1/8" to 3/16" smaller than opening to allow for movement of frame

Safety glass will be installed in accordance with local codes

Push points will be provided on each side to secure glass in frame

Glazing compound will be added in accordance with manufacturer specifications

Objective(s):

Ensure glazing compound will adhere to sash

Install, seal, and secure new glass in place

Allow glazing compound to harden to ensure secure installation

Tools:

1. Caulk gun
2. Tape measure
3. Paint brush

Materials:

1. Primer
2. Window glazing
3. Push points
4. Shims
5. Replacement glass
6. Tape



With sash prepared, installation of new pane can begin



Replacement glass should be securely fixed with points and glazing

3.1203.1c

Desired Outcome:

Replacement window provides weather tight fit; improved energy efficiency performance of fenestration

Specification(s):

Replacement window will be installed in accordance with manufacturer specifications, ensuring that the exterior stops are caulked

Objective(s):

Ensure replacement window operates properly

Ensure replacement window has a weather tight fit



Window opening ready to receive replacement window



Replacement window installed, with stop molding replaced and caulked

Tools:

1. Utility knife
2. Hammer
3. Sharp-bladed prybar
4. Nail set punch
5. Cordless driver/drill
6. Caulking gun
7. HEPA vacuum (for lead-based paint work)

Materials:

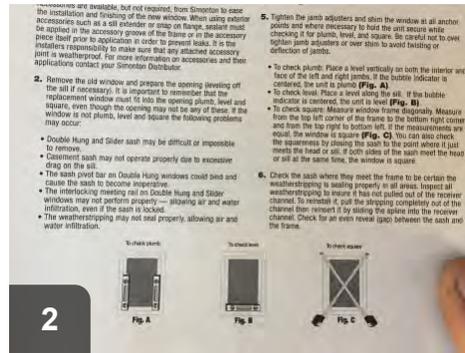
1. Window, door, and trim caulk
2. 6-mil polyethylene plastic

3.1203.1b

3.1203.1c - Replacement window installation



1 Prepare and clean opening before installing new window



2 Check opening for plumb, level, and square



3 Measure diagonally both ways across opening. If measurements are equal, the opening is square



4 Apply caulk to stop molding and install the new window in accordance with manufacturer's instructions.



5 Tighten jamb adjusters and shim as necessary to achieve plumb, level, and square. Fasten window into opening



6 Make sure the sashes open, close, and lock properly. Check that the sashes are parallel with the frame as shown



7 Caulk new window to existing stop molding



8 Reinstall and caulk interior stop molding



9 Completed installation

3.1203.2b

Desired Outcome:

Replacement window provides weather tight fit; improved energy efficiency performance of fenestration

Specification(s):

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 in accordance with accepted industry standards

Objective(s):

Provide a clean and properly flashed opening for replacement window unit

Tools:

1. Pry bar
2. Utility knife
3. Drill

Materials:

1. Window and door flashing



Single pane window in newer home



Window is removed to allow for replacement with double pane unit

3.1203.2c; 3.1203.2d

3.1402.1a

Desired Outcome:

Air leakage prevented and indoor air quality protected

Specification(s):

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

Objective(s):

Ensure resulting closure is permanent and supports any load (e.g., insulation)

Ensure sealant does not fall out

Tools:

1. Headlamp

Materials:

1. Backer rod
2. Sealant



Gaps around floor penetrations, such as plumbing, HVAC, and electrical



Gaps should be sealed to maintain air barrier

4.1301.1a; 4.1301.2a; 4.1301.3a; 4.1301.4a; 4.1301.6a; 4.1301.7a

4.1301.8a

3.1402.1b

Desired Outcome:

Air leakage prevented and indoor air quality protected

Specification(s):

Sealants will be used to fill holes no larger than recommended by manufacturer specifications

Sealants will be compatible with their intended surfaces

Sealants will allow for differential expansion and contraction between dissimilar materials

Sealants will be continuous and meet fire barrier specifications, according to authority having jurisdiction

Objective(s):

Create a permanent seal

Ensure sealant meets or exceeds the performance characteristics of the surrounding materials

Tools:

1. Caulk gun
2. Spray foam gun

Materials:

1. Caulk
2. Spray foam



Avoid sealants that do not allow for expansion between dissimilar materials



Flexible sealants compensate for differential expansion and maintain a seal

3.1402.3a

Desired Outcome:

Well-sealed exterior wall prevents leakage and pests

Specification(s):

Penetrations will be sealed with a durable material

A minimum expected service life of 10 years will be ensured

Objective(s):

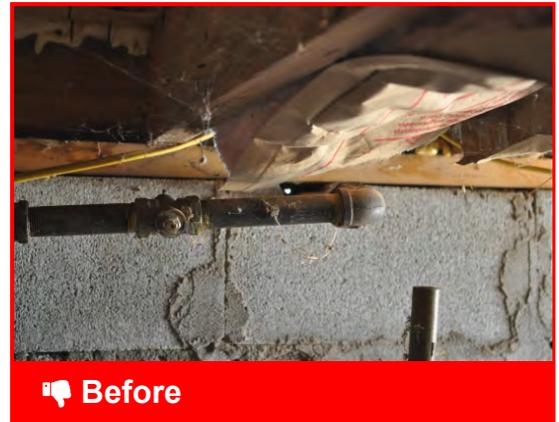
Prevent air and moisture penetration into crawl space

Tools:

- 1. Caulk gun
- 2. Sprayfoam gun
- 3. Metal snips
- 4. Drill

Materials:

- 1. Caulk
- 2. Sprayfoam
- 3. Metal mesh
- 4. Fasteners



Light showing through penetration in exterior block wall



Sealed with durable material to prevent air and water leakage, and pests

3.1402.3b

3.1501.1a

Desired Outcome:

Openings from garage sealed to prevent leakage

Specification(s):

All lighting fixtures, wiring, plumbing, venting, ducting, and gas piping penetrations will be sealed

Objective(s):

Prevent air leakage and pollutant entry

Materials:

1. Backer Rod
2. Caulk
3. Spray foam



Penetrations between the garage and house can leak hazardous fumes



Seal penetrations to minimize risks and air leakage

3.1501.1b

Desired Outcome:

Openings from garage sealed to prevent leakage

Specification(s):

All joints and connections in ductwork will be fastened and sealed with UL 181B or 181B-M welds, gaskets, adhesive mastics, or mastic-plus- embedded-fabric systems

Objective(s):

Prevent air leakage and pollutant entry

Materials:

1. Mesh tape
2. Mastic



 Before

Unsealed joints and connections need to be sealed to prevent health risks.



 After

Sealed ductwork connections help prevent leakage.

3.1602.1c; 3.1602.5c; 4.1601.2b

3.1501.1c

Desired Outcome:

Openings from garage sealed to prevent leakage

Specification(s):

All cracks in house and garage separation wall will be sealed, including cracks between mud sill, rim joists, subfloors, and bottom of gypsum board, ensuring the air sealing enhances the integrity of the fire resistance construction of that wall

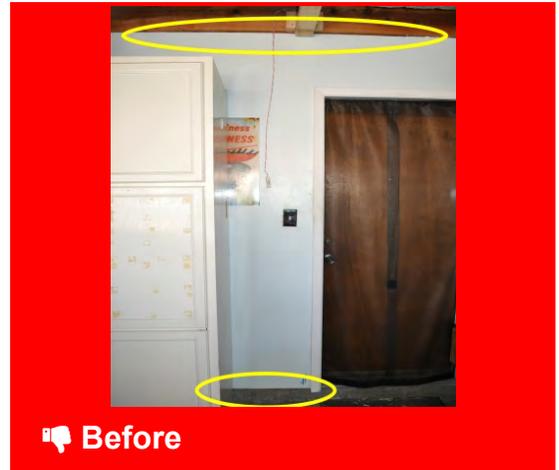
All cracks in ceiling surfaces will be sealed

Objective(s):

Prevent air leakage and pollutant entry

Materials:

- 1. Sprayfoam
- 2. Fire-block caulk



Cracks in shared walls of attached garages are a potential leakage site



Air sealing reduces pollutant entry, but does not diminish fire resistance

3.1501.1g

Desired Outcome:

Openings from garage sealed to prevent leakage

Specification(s):

Occupant will be educated on need to keep door from garage to house closed and not to warm up vehicles or use any gas engine appliances or grills in the garage, even if the main door is left open

Objective(s):

Reduce risk of CO poisoning inside of garage and adjacent rooms



Unsafe

Communicate importance of never running vehicles in a closed garage



Best Practice

Speak with occupant about hazards of using gas appliances in the garage

3.1501.1g - Occupant education



Occupants should never run vehicles in a closed garage



Occupants should not light combustibles inside garages



Speak with occupant about hazards of using gas appliances in the garage

3.1601.3a

Desired Outcome:

Ducts and plenums properly supported

Specification(s):

Flexible and duct board ducts and plenums will be supported every 4' using a minimum of 1 1/2" wide material

Support materials will be applied in a way that does not crimp ductwork or cause the interior dimensions of the ductwork to be less than specified (e.g., ceiling, framing, strapping); duct support must be installed in accordance with authority having jurisdiction

Metal ducts will be supported by 1/2 inch wide eighteen gauge metal straps or 12-gauge galvanized wire at intervals not exceeding 10 feet or other approved means

Objective(s):

Eliminate falling and sagging

Tools:

1. Metal snips
2. Utility knife
3. Drill
4. Stapler

Materials:

1. 18 gauge metal strap (at least 1/2" wide)
2. 12 gauge galvanized wire
3. Fabric support straps (at least 1 1/2" wide)
4. Staples
5. Fasteners



Ducts should not be allowed to droop and drag, adding distance to run



Properly supported ducts minimize heat loss and maximize duct run

3.1601.3a - Support (applies to all duct types)



BAD: Make sure supports **DO NOT** compress insulation or duct



Flex ducts should have supports no less than every 4 feet



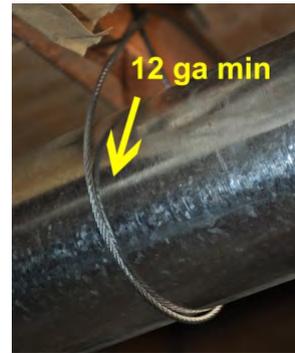
Durable strap should be at least 1 1/2 inches wide



Metal ducts should be supported every 10 feet or less with straps or wire



Metal straps should be at least 18 gauge and 1/2 inch wide



Metal wire should be at least 12 gauge and galvanized

3.1602.4a

Desired Outcome:

Ducts and plenums sealed to prevent leakage

Specification(s):

All gaps between boot and interior surface that defines conditioned space will be air sealed

Gypsum edge will be wetted before applying water-based sealant

Sealants will be continuous and be in accordance with ND State Building Code

Objective(s):

Prevent air leakage

Prevent a fire hazard

Tools:

1. Utility knife
2. Spray bottle
3. Putty knife

Materials:

1. Mastic
2. Mesh tape



Gaps around duct boots allow for leakage to and from the attic



Use a mesh in mastic system to seal duct boot to interior surface

3.1602.4a - Duct boot to interior surface



1
Remove grill to expose duct boot and gaps



2
Wet the edges of the drywall to ensure a good bond



3
Cut mesh tape to fit around duct boot and cover gaps



4
Apply mastic over mesh tape to create heat resistant, durable bond



5
Once mastic is set, grill can be replaced and mastic should not show

3.1602.4b

Desired Outcome:

Ducts and plenums sealed to prevent leakage

Specification(s):

Accessible connections and joints will be made airtight using approved material

Objective(s):

Ensure ducts and plenums will not leak



Locate unsealed ducts constructed from building cavities



Return plenum lined with fiberglass duct board and sealed with mastic

Tools:

1. disposable brushes
2. tape measure
3. utility knife
4. rubber gloves
5. framing square or T-square
6. tin snips

Materials:

1. mastic
2. fiberglass duct board
3. UL 181 listed mastic tape
4. spray polyurethane foam
5. sheet metal
6. screws

Use approved materials to seal ductwork; cover organic materials with airtight, non-organic material such as mastic, metal, or duct board.

From NFPA 90B 4.2.1.3: "The interior of combustible ducts shall be lined with noncombustible material at points where there might be danger from incandescent particles dropped through the register or heater, such as directly under floor registers, the bottom of vertical ducts, or heaters having a bottom return."

From NFPA 90B 4.3.1.1: "Duct coverings, duct linings, and tapes used in duct systems shall have a maximum flame spread index of 25 without evidence of continued progressive combustion and a

maximum smoke developed index of 50 when tested in accordance with ASTM E 84 or ANSI/UL 723..."

3.1602.4c

Desired Outcome:

Ducts and plenums sealed to prevent leakage

Specification(s):

Joints will be closed and cracks and holes not needed for proper function of unit will be sealed using removable sealant (e.g., foil tape) or in accordance with the original equipment manufacturer directions (if available)

Objective(s):

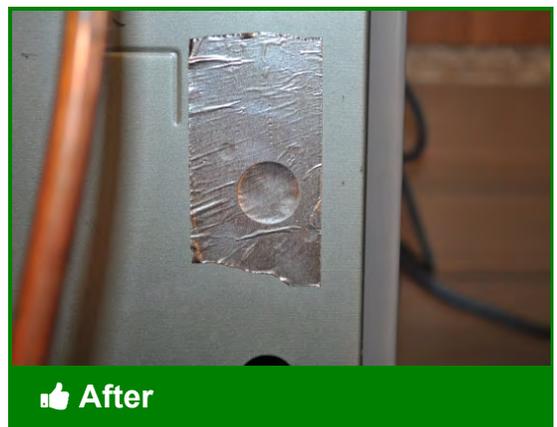
Reduce air leakage while maintaining accessibility

Materials:

- 1. Foil tape



Unnecessary holes in the air handler cabinet need to be sealed



Use removable foil tape to seal holes

3.1602.4d

Desired Outcome:

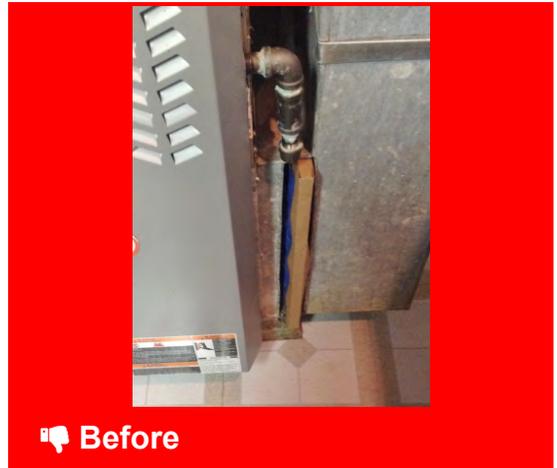
Ducts and plenums sealed to prevent leakage

Specification(s):

A pre-manufactured or site manufactured durable filter slot cover will be installed

Objective(s):

Reduce air leakage while maintaining accessibility



Uncovered filter slots are a point of leakage



Filter slots should be covered

3.1602.5a

Desired Outcome:

The return duct installed to prevent air leakage

Specification(s):

Debris and dirt will be cleaned out of the return platform

Objective(s):

Allow for the application of rigid materials and sealants

Tools:

1. Shop vacuum



Dirty, unsealed return platform needs to be cleaned out before sealing



Vacuum out debris and dirt from the return to prepare work area

3.1602.5b

Desired Outcome:

The return duct installed to prevent air leakage

Specification(s):

Backing or infill will be provided as needed to meet the specific characteristics of the selected material and the characteristics of the open space

Backing or infill will not bend, sag, or move once installed

Material will be rated for use in return duct systems

Objective(s):

Minimize hole size to ensure successful use of sealant

Ensure closure is permanent and supports any load (e.g., return air pressure)

Ensure sealant does not fall out

Tools:

1. Tape measure
2. Utility knife
3. Drill
4. Caulk gun

Materials:

1. XPS
2. Drywall
3. Fire-resistant caulk
4. Fasteners



Leakage from air return into wall cavities should be eliminated

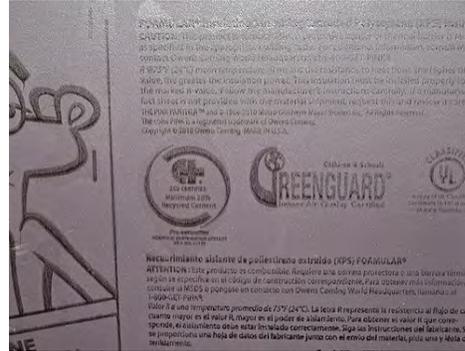


Only materials rated for use in higher temperature areas should be used

3.1602.5b - Infill and backing



Do NOT use EPS in air returns due to proximity to combustion appliances



XPS (extruded polystyrene) and drywall are safe for use in air returns

4.1001.1a

Desired Outcome:

Ensure safety from fire and prevent air leakage

Specification(s):

A fire-rated air barrier system (i.e., equivalent to 5/8 fire code gypsum wallboard) will be used to separate non-IC rated recessed lights from insulation, using one of the methods below:

A fire-rated 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

OR

The fixture(s) may be replaced with surface mounted fixture and opening sealed

OR

Air sealing measures as approved by the authority having jurisdiction

Objective(s):

Prevent a fire hazard

Prevent air leakage through fixture

Tools:

1. Utility knife
2. Tape measure

Materials:

1. 5/8" fire-rated drywall
2. Fire-rated caulk sealant



Before

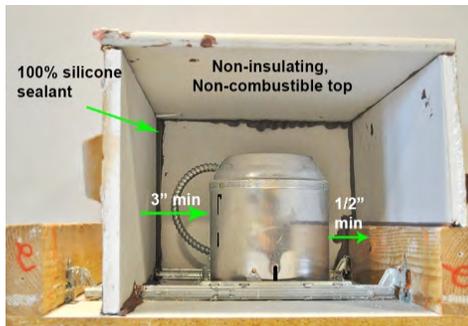
Non-IC rated recessed light fixtures should be dammed from insulation



After

Sealed box around non-IC light should be taller than surrounding insulation

4.1001.1a - Air barrier system



Box should be constructed with clearances in mind



Sealed box should be constructed of fire-rated drywall



OR non-IC can light can be replaced with IC-rated recessed light

4.1001.1b; 4.1001.1c; 4.1001.1d

4.1001.3a

Desired Outcome:

Combustible materials kept away from combustion sources

Specification(s):

Holes, penetrations, and bypasses will be sealed

Dams will be fixed in places that maintain required clearance

Objective(s):

Prevent air leakage

Ensure insulation dams maintain clearance

Tools:

1. Metal snips
2. Caulk gun
3. Fasteners

Materials:

1. 26-gauge steel sheeting
2. High temperature caulk
3. Caulk
4. Backer rod
5. Spray foam



🗨 Before

Gaps and penetrations in attic need to be sealed to maintain air barrier



👍 After

Chimneys, flues, and light fixtures should be dammed to prevent fire

4.1001.3a - Verify attic prep



Gaps around flues and penetrations need to be sealed before insulating



High temperature caulk should be used for flues and chimneys



26-gauge steel should be used to construct seals and dams on flues



Only construct dam after sealing has been completed properly



Dammed chimneys, flues and light fixtures prevent fires

4.1001.3b

Desired Outcome:

Combustible materials kept away from combustion sources

Specification(s):

A rigid dam having a height greater than the insulation to be installed will be constructed to ensure a 3" clearance between combustion flue vent and dam

Chimney vents will have an airspace clearance to combustibles in accordance with ND State Building Code

Objective(s):

Ensure dam material does not bend, move, or sag

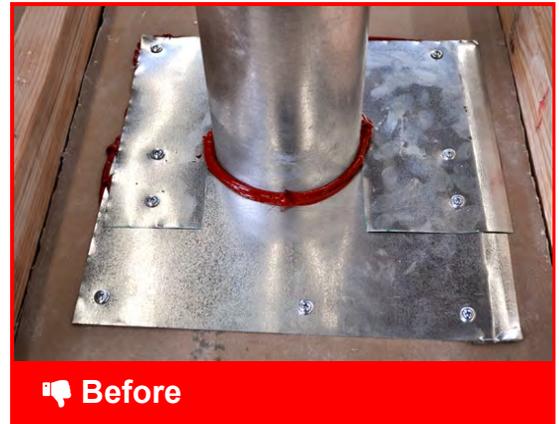
Prevent a fire hazard

Tools:

1. Metal snips

Materials:

1. 26-gauge steel sheeting
2. Fasteners



 Before

To prevent fire hazards, flues, chimneys, and light fixtures require dams



 After

Observe a 3 inch minimum clearance for dams around flues and chimneys

4.1001.3d

Desired Outcome:

Provide occupant with documentation of installation

Specification(s):

Documentation of material and R-value will be provided to occupant

Objective(s):

Provide occupant with documentation of installation



Best Practice

Provide occupant with documentation of and about insulation installed

4.1003.3c; 4.1005.1c; 4.1005.3e; 4.1005.3e; 4.1088.3c; 4.1301.2d;

4.1302.1d; 4.1301.3d; 4.1301.1d; 4.1301.4d; 4.1301.5e; 4.1301.6e

4.1301.7d; 4.1301.8d; 4.1103.1b; 2.0213.2g; 4.1003.3e; ;

4.1001.4a

Desired Outcome:

Attic ventilation meets code requirements and insulation is protected from wind washing

Specification(s):

If soffit venting or eave venting is present, baffles will be mechanically fastened to block wind entry into insulation or to prevent insulation from blowing back into the attic

If soffit venting or eave venting is present, baffles will be installed to maintain clearance between the roof deck and baffle in accordance with manufacturer specifications

Installation will allow for the highest possible R-value above the top plate of the exterior wall

Objective(s):

Ensure insulation R-value is not reduced

Maintain attic ventilation

Tools:

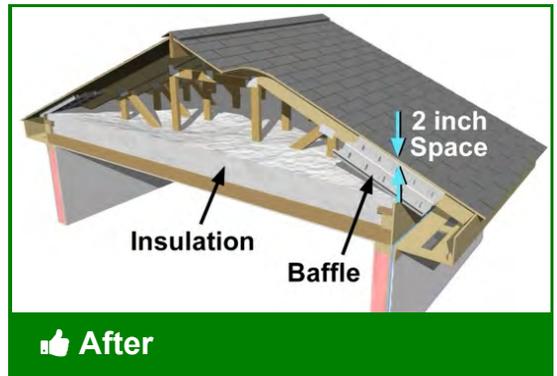
1. Stapler

Materials:

1. Baffles
2. Staples



Insulation should not block vented eaves



Baffles installed in vented attics to allow air flow past insulation

4.1003.3a

Desired Outcome:

Insulation reduces heat flow through unvented roof

Specification(s):

Code compliant ventilation will be installed before insulation

Objective(s):

Reduce possibility of moisture issues

Tools:

1. Saw
2. Grinder
3. Metal snips
4. Drill

Materials:

1. Metal lath
2. Stucco



Unvented flat roofs should have venting installed



Vents in the space below the roof help maintain proper air flow

4.1003.3b

Desired Outcome:

Insulation reduces heat flow through unvented roof

Specification(s):

Roof cavities will be blown with loose fill insulation (or roof cavities will be dense packed with insulation) without gaps, voids, compressions, misalignments, or wind intrusions

Insulation will be installed to prescribed R-value

Objective(s):

Insulate to prescribed R-value

Tools:

1. Insulation machine

Materials:

1. Loose fillable or dense packable insulation



Before

Vent reveals attic is insulated with old rug -- not adequate.



In Progress

Attic will be dense packed to r-value specified on Work Order.

4.1004.1a

Desired Outcome:

Airtight cavity and insulated knee wall

Specification(s):

All knee walls will have top and bottom plate or blockers installed using rigid materials

When knee wall floor and walls are being insulated, the floor joist running under the knee wall will be air sealed

If fabric is used before dense packing, it will be secured, according to manufacturers specifications or with furring strips every wall stud

If rigid material is used, material will be installed to cover 100% of the surface of the accessible knee wall area

If foam sheathing is used, sheathing will be listed for uncovered use in an attic or covered with a fire barrier

Objective(s):

Eliminate bending, sagging, or movement that may result in air leakage

Prevent air leakage through the top or bottom of the knee wall

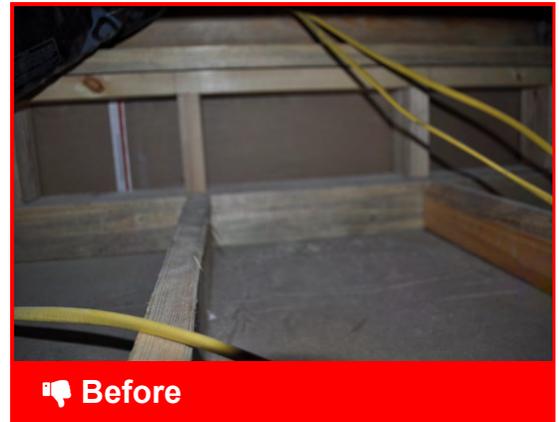
Ensure material will not tear under stress from wind loads or insulation

Tools:

1. Tape measure
2. Utility knife
3. Caulk gun
4. Spray foam gun
5. Drill
6. Stapler

Materials:

1. Drywall
2. XPS
3. Caulk
4. Spray foam
5. Fasteners
6. Staples



Before

Knee walls often need sealing and insulation



After

Knee wall is prepped for dense pack insulation

4.1004.1a - Backing



Knee walls missing top plates need one created from rigid material



Top plate holds dense pack insulation in cavity



New top plate should be sealed to surrounding joists and studs



Bottom plates also need to be installed. Measure for size



Cut to size and attempt to install in line with air barrier above



Seal to surrounding joist



If using house-wrap or fabric, tack in place with furring strips or staples



Drywall is also a good barrier for dense packing knee walls

4.1004.1b

Desired Outcome:

Airtight cavity and insulated knee wall

Specification(s):

All existing batted insulation will be adjusted to ensure it is in full contact with the interior cladding and the 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

Follow manufacturer's requirements for fiberglass dense pack applications

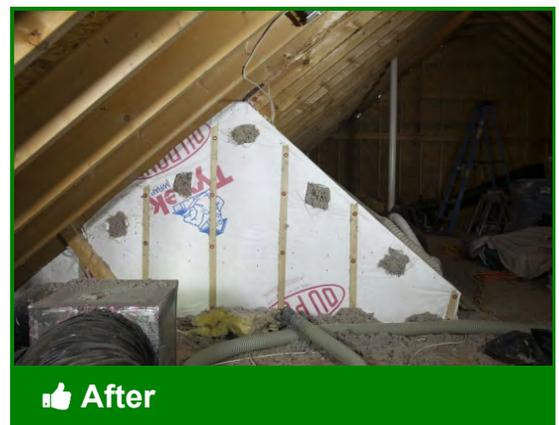
Objective(s):

Eliminate misalignment of existing insulation

Prevent insulation from settling or moving



Existing batt insulation should be adjusted to fit properly



If properly dense-packed, insulation should hold in place when finished

4.1004.1b - Installation



Attach furring strips to create pockets for dense-pack insulation



Insulation should meet manufacturer specifications for density.

4.1004.2a

Desired Outcome:

Airtight cavity and properly insulated knee wall

Specification(s):

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

Objective(s):

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

Tools:

1. Spray foam gun
2. Caulk gun
3. Tape measure
4. Utility knife
5. Drill
6. Saw

Materials:

1. XPS
2. Lumber
3. Caulk
4. Spray foam
5. Fasteners



Top plate is missing from knee wall



New top plate is sealed to adjacent framing

4.1005.2b

4.1004.2b

Desired Outcome:

Airtight cavity and properly insulated knee wall

Specification(s):

Insulation will be installed using one of the following methods:

- New batts will be installed in accordance with manufacture specifications
- All existing batted insulation will be adjusted to ensure it is in full contact with the interior cladding and the top and bottom plates

Objective(s):

Eliminate misalignment of existing insulation

Tools:

1. Utility knife
2. Tape measure

Materials:

1. Fiberglass batts



Before

Knee wall with batts improperly installed and missing from stud bays



After

Properly fit insulation filling full volume of stud bay

4.1004.2c

Desired Outcome:

Airtight cavity and properly insulated knee wall

Specification(s):

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 attic, or covered with a fire barrier

Objective(s):

Prevent insulation from settling or moving

Tools:

1. Utility knife
2. Tape measure
3. Drill

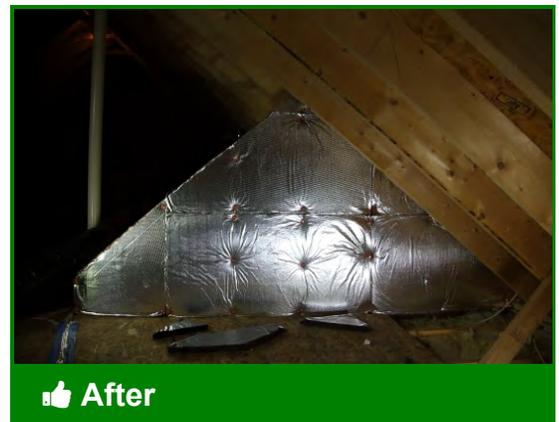
Materials:

1. Drywall
2. House wrap



 Before

Knee walls with batt insulation require covering



 After

Foam sheathing? Needs to be covered with a fire barrier

4.1004.2c - Backing knee wall



Fiberglass batts in attic knee walls can be held in place by house wrap



If foam sheathing is used, it needs to be covered with a fire barrier

4.1005.1a

Desired Outcome:

Consistent, thermal boundary between conditioned and unconditioned space controls the heat flow

Specification(s):

Subfloor or drywall will be removed to access cavities as necessary, including inaccessible knee-wall attic floor spaces

All electrical junctions will be flagged to be seen above the level of the insulation

Open electrical junction boxes will have covers installed

Objective(s):

Access the workspace

Provide location of electrical junctions for future servicing

Prevent an electrical hazard

Tools:

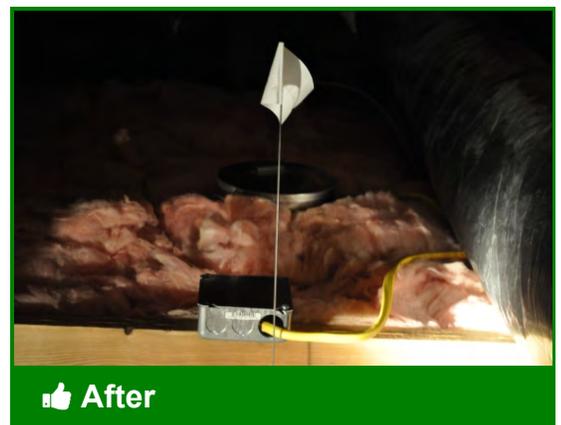
1. Hammer
2. Pry bar

Materials:

1. Flags



Remove flooring in attic spaces to access floor cavities and insulate



Flag electrical junctions to make future maintenance and repairs easier

4.1005.2a

Desired Outcome:

Consistent, thermal boundary between conditioned and unconditioned space controls the heat flow

Specification(s):

Subfloor or drywall will be removed to access cavities as necessary, including inaccessible knee-wall attic floor spaces

Insulation will be adequately marked for depth a minimum of every 300 square feet of attic area, with measurement beginning at the air barrier

All electrical boxes will be flagged to be seen above the level of the insulation

Open electrical junctions will have covers installed

Insulation dams and enclosures will be installed as required

Objective(s):

Access the workspace

Verify uniformity of insulation material

Provide location of electrical boxes for future servicing

Prevent an electrical hazard

Tools:

1. Pry bar
2. Hammer
3. Caulk gun
4. Utility knife
5. Staple gun
6. Spray foam gun
7. Tape measure

Materials:

1. Flags
2. Depth markers
3. Staples
4. XPS
5. Caulk
6. Spray foam



Accessible attic floors should be air sealed and insulated



Depth markers and insulation dams aid in proper insulation of attic spaces

4.1005.2a - Preparation



Check cavity for electrical junctions and penetrations



Flag and install covers on electrical junctions



Seal any penetrations



Non-IC (insulation contact) can lights should be covered with a dam and have no insulation on top



Install depth markers and insulation dams above height of insulation

4.1005.1b; 4.1005.1a

4.1005.2b

Desired Outcome:

Consistent, thermal boundary between conditioned and unconditioned space controls the heat flow

Specification(s):

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

Objective(s):

Hold dense pack in place

Tools:

1. Tape measure
2. Utility knife
3. Saw
4. Drill
5. Spray foam gun
6. Caulk gun

Materials:

1. Spray foam
2. XPS
3. Drywall
4. Plywood
5. Fasteners
6. Caulk sealant



When missing, bottom plates must be installed under knee walls



New bottom plates complete air barrier and hold insulation in place

4.1005.2c

Desired Outcome:

Consistent, thermal boundary between conditioned and unconditioned space controls the heat flow

Specification(s):

All insulation will be installed to the depth indicated on the manufacturer coverage chart for desired R-value

Objective(s):

Reduce heating and air conditioning costs

Improve comfort

Minimize noise

Tools:

1. Insulation machine

Materials:

1. Loose fill insulation



Accessible attic floor should be air sealed and insulated



Check chart on package to ensure proper insulation depth to achieve R-value

R-Value @ 157		Minimum Depth (inches)		No. Joists (16" o.c. spacing)			2" x 8", 16" O.C.		
R-Value @ 157	Insulation Thickness (inches)	Minimum Depth (inches)	Quantity (bags per 100 sq. ft.)	Depth Per 100 Sq. Ft.	Air Coverage Sq. Ft. Per Bag	Minimum Weight Per Sq. Ft.	Depth Per 100 Sq. Ft.	Air Coverage Sq. Ft. Per Bag	Minimum Weight Per Sq. Ft.
13	4.4	4.0	17.4	67.5	0.38	15.8	63.5	0.35	0.56
19	6.1	5.5	27.9	35.5	0.61	25.3	39.6	0.57	0.87
22	6.9	6.2	33.2	30.1	0.73	30.5	32.8	0.79	1.00
25	7.8	7.0	38.6	25.9	0.85	35.8	28.0	0.98	1.13
30	9.2	8.3	47.6	21.0	1.00	44.6	22.4	1.20	1.30
38	11.4	10.3	62.0	16.1	1.26	69.9	17.0	1.73	1.73
49	14.6	13.1	82.0	12.2	1.80	78.7	12.7	2.17	2.17
60	17.7	15.9	101.9	9.8	2.24	96.6	10.1	2.17	2.17

4.1005.2d

Desired Outcome:

Consistent, thermal boundary between conditioned and unconditioned space controls the heat flow

Specification(s):

A dated receipt signed by the installer will be provided that includes:

- Insulation type
- Coverage area
- R-value
- Installed thickness and settled thickness
- Number of bags installed in accordance with manufacturer specifications

Objective(s):

Document job completion to contract specifications

Confirm amount of insulation installed

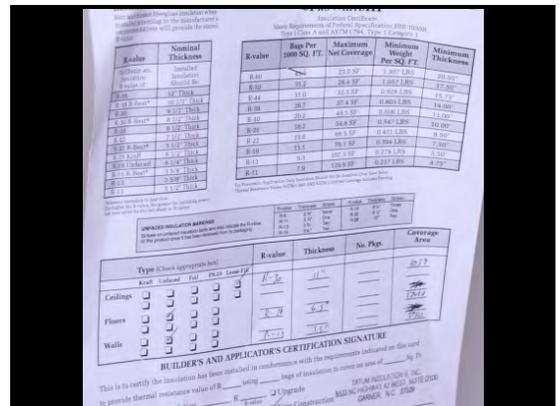
Ensure ability to match bags required for total area completed

Comply with 16 CFR 460.17



Best Practice

Information on insulation installed should be posted nearby



Best Practice

Posted info includes insulation type, r-value, depth, coverage area, etc.

Paraphrased from 16 CFR 460.17: If you are an installer, you must give your customers a contract or receipt for the insulation you install. For loose-fill, the receipt must show the coverage area, initial installed thickness, minimum settled thickness, R-value, and the number of bags used. 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.

4.1005.4d; 4.1005.5d

4.1005.5a

Desired Outcome:

A consistent thermal boundary between conditioned and unconditioned space controls the heat flow

Specification(s):

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

Objective(s):

Hold dense pack in place

Tools:

1. Drywall saw
2. Utility knife
3. Tape measure
4. Straight edge

Materials:

1. XPS or other rigid material



Before

This finished garage below a bonus room is an unconditioned space



After

Rigid material forms an air barrier located under the bonus room stem wall

4.1005.5b

Desired Outcome:

A consistent thermal boundary between conditioned and unconditioned space controls the heat flow

Specification(s):

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 fiberglass material will be installed and will be specifically approved for air flow resistance to a minimum density per the manufacturer's recommendations

The number of bags installed will be confirmed and will match the number required on the coverage chart

Insulation will be verified to prevent visible air movement using chemical smoke at 50 pascals of pressure difference

Objective(s):

Eliminate voids and settling

Minimize framing cavity air flows

Tools:

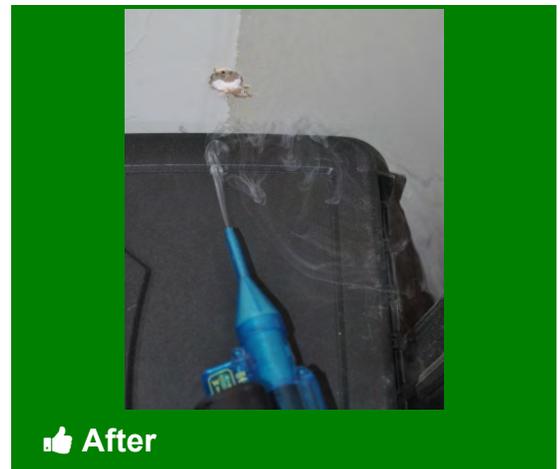
1. Insulation machine
2. Drill
3. Smoke pencil
4. Blower door
5. Small hole saw bit

Materials:

1. Cellulose insulation
2. Dense packable insulation
3. Spackle
4. Seam tape



With rigid block in place under bonus room stem wall, insulation can begin



Chemical smoke at 50pa indicates insulation is at appropriate density

4.1005.5c

Desired Outcome:

A consistent thermal boundary between conditioned and unconditioned space controls the heat flow

Specification(s):

Insulation will not be allowed on top of non-IC rated can light boxes or between a heat-generating appliance and a dam, unless material is rated for contact with heat generating sources

Objective(s):

Prevent a fire hazard



 Before

Dams around flues, chimneys, and light fixtures should hold back insulation



 After

Clear dams of any insulation or debris in order to minimize risk of fire

4.1006.1a

Desired Outcome:

Pull-down attic stair properly sealed and insulated

Specification(s):

Hatches will be insulated to the maximum R-value structurally allowable up to the R-value of the adjoining insulated assembly

Pull-down stair rough opening will be surrounded with a durable dam that is higher than the level of the attic floor insulation

Counter-weights should be considered to ease accessibility for excessively heavy hatches

Objective(s):

Achieve uniform R-value

Prevent loose insulation from entering the living area

Tools:

1. Tape measure
2. Drill
3. Saw
4. Caulk gun

Materials:

1. Caulk sealant
2. Lumber
3. XPS
4. Pre-fabricated stairwell cover



Insulation needs to be dammed to keep from falling through during operation



Insulated pull-down stairs cover installed to prevent air leakage

4.1006.1b

Desired Outcome:

Pull-down attic stair properly sealed and insulated

Specification(s):

Entire pull-down stair assembly will be covered with an airtight and removable/openable enclosure inside the attic space

Pull-down stair frame will be caulked, gasketed, weatherstripped, or otherwise sealed with an air barrier material, suitable film, or solid material that allows attic door operation

Objective(s):

Prevent air leakage

Tools:

1. Caulk gun

Materials:

1. Weatherstripping
2. Spray foam
3. Caulk



Unsealed pull-down stairs leads to air leakage to and from the attic



To preserve thermal envelope, an airtight seal needs to be created

4.1006.2a

Desired Outcome:

Attic access door properly sealed and insulated

Specification(s):

Hatches will be insulated to the maximum R-value structurally allowable up to the R-value of the adjoining insulated assembly

Attic hatches rough opening will be surrounded with a durable protective baffle that is higher than the level of the surrounding attic floor insulation

Objective(s):

Achieve uniform R-value on the attic door or hatch

Achieve uniform R-value on the attic floor

Prevent loose attic floor insulation from entering the living area

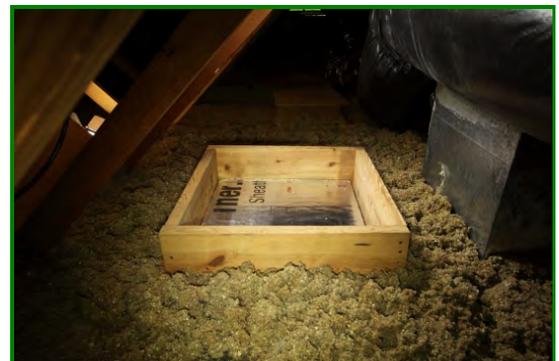
Materials:

1. XPS
2. Lumber
3. Weatherstripping
4. Fasteners



 Before

Uninsulated attic hatches and access panels weaken the thermal envelope



 After

Hatch cover or panel access door should match r-value of attic insulation

4.1006.2b

4.1006.2c

Desired Outcome:

Attic access door properly sealed and insulated

Specification(s):

Insulation will be permanently attached and in complete contact with the air barrier

Objective(s):

Insulate to prescribed R-value

Tools:

1. Caulk gun
2. Utility knife

Materials:

1. XPS
2. Adhesive



 Before

Unsealed and uninsulated attic hatches and access doors allow leakage



 After

Rigid insulation on back of new hatch cover attached firmly and squarely to allow for airtight fit

4.1088.3b

Desired Outcome:

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

Specification(s):

Insulation will be installed in accordance with manufacturer specifications and will be in full contact with all sides of existing cavity without gaps, voids, compressions, misalignments, or wind intrusions

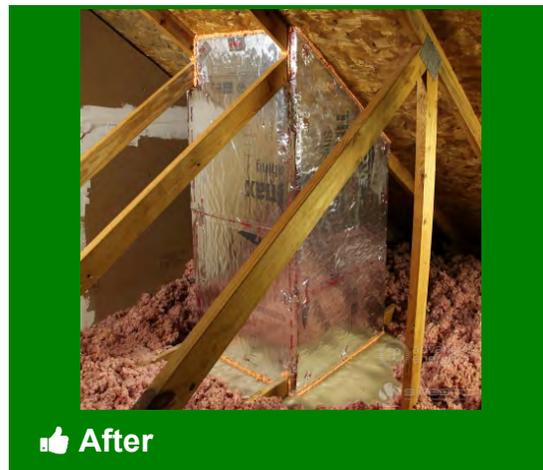
Insulation will be installed to prescribed R-value

Objective(s):

Insulate to prescribed R-value



Uninsulated, unsealed skylight well



Insulated, air sealed skylight well

Tools:

1. stapler
2. tape measure
3. utility knife
4. caulking gun
5. foam gun

Materials:

1. caulk
2. one-part foam sealant
3. insulation (fiberglass, cellulose, spray polyurethane foam, polyisocyanurate board, extruded polystyrene board, or other as needed to achieve specified R-value)
4. air barrier material (drywall, foam board, paneling, hardboard, etc.)

Air-permeable insulation such as fiberglass or cellulose should be covered with a sealed attic-side air barrier.

4.1102.1a

Desired Outcome:

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

Specification(s):

Holes and penetrations will be sealed

Bypasses will be blocked and sealed

Objective(s):

Prevent air leakage

Tools:

1. Caulk gun

Materials:

1. Backer rod
2. Spray foam
3. Caulk



Penetrations and bypasses create places where blown in insulation can leak



Sealed penetrations offer leakage protection and keep insulation in place

4.1102.1b

Desired Outcome:

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

Specification(s):

Insulation will be installed in accordance with manufacturer specifications without gaps, voids, compressions, misalignments, or wind intrusions

Insulation will be installed to prescribed R-value

Objective(s):

Insulate to prescribed R-value

Tools:

1. Insulation machine
2. Staple gun

Materials:

1. Loose fillable insulation
2. Netting
3. Staples
4. Fiberglass batts



🗨️ Before

Open walls should be insulated



👍 After

Well-insulated rooms are significantly more comfortable in all seasons

4.1102.1c

Desired Outcome:

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

Specification(s):

Verification of complete installation without gaps, voids, compressions, misalignments, or wind intrusions will be provided

Objective(s):

Install insulation correctly

Tools:

1. Hands
2. Eyes



🗨️ Before

Verify insulation is properly installed before drywalling



👍 After

Once proper installation is verified, begin drywalling to finish wall

4.1103.1a

Desired Outcome:

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

Specification(s):

Using fill tube, 100% of each cavity will be filled to a consistent density:

- Cellulose insulation used in an enclosed cavity will be installed at 3.5 pounds per cubic foot or greater density
- Blown fiberglass, mineral fiber, or rock and slag wool used in an enclosed cavity will be installed at or above the manufacturer recommended density to limit air flow that corresponds to an air permeance value of 3.5 cfm/sq. ft. at 50 pascals, as measured using BPI-102 "Standard for Air Resistance of Thermal Insulation Used in Retrofit Cavity Applications – Material Specification" or ASTM C 522, E 283, or E 2178; the number of bags installed will be confirmed and will match the number required on the coverage chart

Insulation will be verified to prevent visible air movement using chemical smoke at 50 pascals of pressure difference

Objective(s):

Eliminate voids and settling

Minimize framing cavity air flows



Make accurate count of insulation bags to be installed



Install insulation to correct density (at least 3.5 pounds per cubic foot for cellulose, or 1.5 pounds for fiberglass)

4.1103.2a

Desired Outcome:

Properly installed insulation reduces heat flow through walls and framing cavities inaccessible to other treatments

Specification(s):

Details remaining in or between completed wall sections will be located and accessed

Objective(s):

Ensure the last gaps and framing edges in the thermal boundary, roof-wall joints, floor-wall joints, etc., are found and finished

Tools:

1. Infrared camera
2. Drill
3. Hole saw
4. Tape measure
5. Probe



Cavities missing insulation allow greater heat transfer than insulated ones



Either from inside or outside, using IR camera to locate cavities for fill

4.1103.2b

Desired Outcome:

Properly installed insulation reduces heat flow through walls and framing cavities inaccessible to other treatments

Specification(s):

Backing will be provided and all newly uncovered openings will be sealed with air barriers, foam, or mastic, maintaining all required clearances

Objective(s):

Ensure the air barrier is connected across all accessible house elements

Tools:

1. Caulk gun

Materials:

1. Caulk
2. Backer rod
3. Fire-block, when necessary



Unsealed penetrations should be sealed to ensure insulation stays in place



Once air barrier has been preserved by sealing, insulation can begin

4.1103.2d

Desired Outcome:

Properly installed insulation reduces heat flow through walls and framing cavities inaccessible to other treatments

Specification(s):

Completed wall sections will be viewed using infrared camera with blower door operating

Any voids or low density areas will be drilled and re-packed

Objective(s):

Establish air barrier and thermal boundary

Confirm no voids or hidden air flows remain

Tools:

1. Infrared camera



Uninsulated exterior wall cavities to be insulated



Reduced temperature difference indicating insulated wall cavities

4.1103.2e

Desired Outcome:

Properly installed insulation reduces heat flow through walls and framing cavities inaccessible to other treatments

Specification(s):

Installation holes will be plugged as follows:

- Exterior holes will be weather barrier patched
- Interior holes will be coated and patched to match original interior surface

All construction debris and dust will be collected and removed

Objective(s):

Ensure house is returned to watertight and clean condition

Tools:

1. Taping knife
2. Caulk gun
3. Drill
4. Paint brush

Materials:

1. Spackle
2. House wrap
3. Lath
4. Stucco
5. Fasteners
6. Adhesive
7. Primer
8. Drywall
9. XPS



In Progress

With insulation complete, wall needs to be patched to better-than-found



After

When repair is finished, it shouldn't be obvious any work was done

4.1103.2e - Close holes



For interior access, locate access holes at studs for easier patching



Once drywall patches are spackled, prime and paint.



For exterior access, use a drop cloth or gutter to help with clean up



Plug holes with rigid material that will not move or sag over time



For stucco and plaster patches, lath will need to be used to hold weight



If possible, maintain house wrap, or replace it after holes are plugged



Put siding back in place, or return exterior finish to match remaining wall

4.1301.1b

Desired Outcome:

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

Specification(s):

Insulation will be installed in contact with subfloor without gaps, voids, compressions, misalignments, or wind intrusions

If kraft-faced batts are used, they will be installed with kraft facing to subfloor

Insulation will be installed to prescribed R-value

Objective(s):

Insulate to prescribed R-value

Tools:

1. Utility knife
2. Tape measure

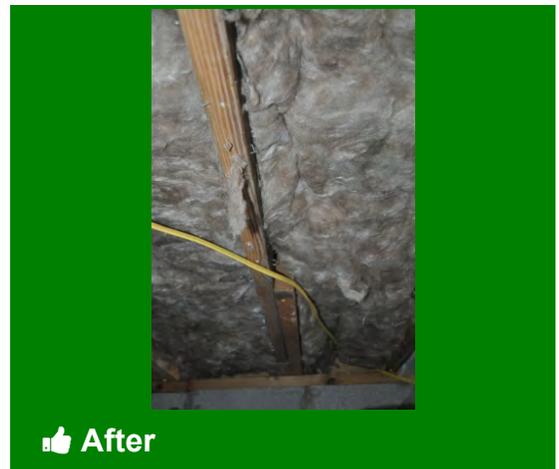
Materials:

1. Kraft-faced fiberglass batts to work order specifications



 Before

Uninsulated floors above unconditioned spaces are an energy drain



 After

Batts should fill most of joist bay and be in full contact with subfloor

4.1301.6b

4.1301.1c

Desired Outcome:

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

Specification(s):

Batts will be secured with physical fasteners

Objective(s):

Ensure insulation remains in contact with subfloor

Tools:

1. Utility knife
2. Drill
3. Staple gun

Materials:

1. Lightning rods
2. Twine
3. Fasteners



Fiberglass batts should not be hanging away from subfloor



"Lightning rods" or twine can be used to hold batts in contact

4.1301.5c; 4.1301.6c

4.1301.2b

Desired Outcome:

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

Specification(s):

When using netting or fabric, staples will be placed according to manufacturer specifications

Netting or fabric will meet local fire codes

Objective(s):

Secure insulation

Tools:

1. Utility knife
2. Scissors
3. Stapler

Materials:

1. Fabric netting
2. Staples



Uninsulated floors above unconditioned spaces are an energy drain



Netting is secured to joists and sills to create cavities for insulation

4.1301.2c

Desired Outcome:

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

Specification(s):

Insulation in netted or fabric cavities will be dense packed with loose fill insulation in accordance with manufacturer specifications

Insulation will be installed to prescribed R-value

Insulation will be in continuous contact with air barrier

Objective(s):

Insulate to prescribed R-value

Ensure a continuous thermal boundary between conditioned and unconditioned space

Tools:

1. Utility knife
2. Insulation machine

Materials:

1. Loose fill fiberglass



In Progress

With netting in place, insulation can begin



After

Cavities filled to manufacturer specs to achieve prescribed r-value

4.1301.3b

Desired Outcome:

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

Specification(s):

A rigid air barrier will be mechanically fastened to underside of floor assembly, providing 100% coverage of the floor assembly

Seams and penetrations will be sealed

Objective(s):

Relocate air barrier

Tools:

1. Utility knife
2. Saw
3. Drill
4. Caulk gun

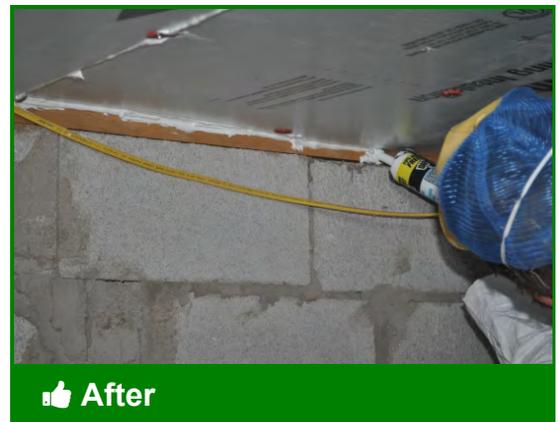
Materials:

1. Rigid material - drywall, XPS, plywood
2. Fasteners
3. Caulk



 Before

Uninsulated floors over unconditioned spaces are an energy drain



 After

Rigid barriers provide air sealing and create cavities for insulation

4.1301.4b; 4.1301.6d; 4.130.7b; 4.1301.8b

4.1301.3c

Desired Outcome:

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

Specification(s):

Loose fill insulation will be installed between air barrier and subfloor according to manufacturer specifications

Insulation will be installed to prescribed R-value

Objective(s):

Insulate to prescribed R-value

Tools:

1. Insulation machine
2. Caulk gun

Materials:

1. Loose fill insulation
2. Caulk



 Before

Once rigid barrier is sealed, insulation can be blown in



 After

4.1301.7c; 4.1301.4c;

4.1301.5a

Desired Outcome:

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

Specification(s):

Air barrier will be installed between joists and sealed

Air barrier will be placed to the most interior edge of the top plate of the wall below

Objective(s):

Separate cantilevered floor from conditioned floor space

Allow for insulation



Before

Cavities are open allowing unconditioned air to communicate within the space between floors.



After

Cavity has been blocked, sealed, and insulated. Rigid air barrier is hidden behind insulation in this photo

Tools:

1. tape measure
2. utility knife
3. flashlight
4. caulking gun
5. foam gun

Materials:

1. rigid air barrier (plywood, OSB, drywall, rigid foam board)
2. caulk or foam sealant
3. dense-pack cellulose or fiberglass insulation
4. batt insulation
5. two-part spray polyurethane foam (optional)

1. Stuff the cavities with fiberglass insulation as a backer, and then apply two-part spray polyurethane foam to seal the openings. 2. Cut and install drywall, plywood, OSB, or rigid foam board in each cavity, then seal around the edges with foam or caulk. 3. Install dense-pack insulation in cantilevered

area, being careful to extend it inward past the supporting wall (this also accomplishes insulating the cantilevered floor area).

Install insulation at the required R-value in permanent contact with the subfloor under the cantilevered section.

4.1301.5a - Air barrier



Measure cavity to determine size necessary for blocking.



Measure and cut blocking to fit snugly between floor joists.



Ensure the blocking is placed to the most interior edge of the top plate of the wall below.



Air seal blocking around its perimeter edges with foam or caulk.



Cut batt insulation to match the size of the blocking.

4.1301.5b

Desired Outcome:

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

Specification(s):

Air barrier will be insulated between joist from top plate of the wall below to subfloor above

Cantilevered subfloor will be insulated in complete contact with the floor without gaps, voids, compressions, misalignments, or wind intrusions

If kraft-faced batts are used, they will be installed with kraft facing to the air barrier

Insulation will be installed to prescribed R-value

Objective(s):

Insulate to prescribed R-value



Cavities are open and subfloor of conditioned space above is uninsulated.



Batt insulation is installed to either fill the cavity or be properly supported to maintain contact with the subfloor.

Tools:

1. drill
2. mechanical fasteners
3. claw hammer or pry bar

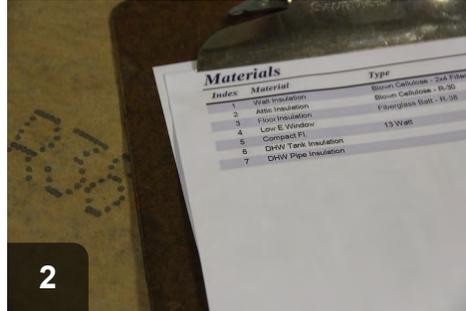
Materials:

1. batt insulation - kraft-faced or unfaced
2. insulation supports

4.1301.5b - Installation



1 Cavities are open and subfloor of conditioned space above is uninsulated.



2 Insulation R-value to be installed matches the work order.



3 Here the worker is removing the kraft facing, which may be needed in some areas.



4 Ensure the batt is positioned correctly.



5 Batt insulation is installed to either fill the cavity or be properly supported to maintain contact with the subfloor.

4.1301.5c

Desired Outcome:

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

Specification(s):

Batts will be secured with physical fasteners

Objective(s):

Ensure insulation remains in contact with subfloor and air barrier



Before

Sagging, unsupported floor insulation is not in contact with the subfloor



After

Fiberglass floor insulation properly installed with wire supports

Tools:

1. Wire cutters
2. Stapler
3. Cordless driver/drill
4. Utility knife

Materials:

1. Wire insulation supports
2. (optional) 1 X 2 furring strips or insulation support netting
3. Staples

<https://www.youtube.com/watch?v=b47hH7HByts>

4.1301.5c

Desired Outcome:

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

Specification(s):

Batts will be secured with physical fasteners

Objective(s):

Ensure insulation remains in contact with subfloor and air barrier



Insulation should be secured to prevent drooping or movement



"Lightning rods" or twine should keep full contact with the subfloor

Tools:

1. Utility knife
2. Drill
3. Staple gun

Materials:

1. Lightning rods
2. Twine
3. Fasteners

4.1301.5d

Desired Outcome:

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

Specification(s):

Exterior soffit material will be installed and sealed

Objective(s):

Cover and protect insulation



 Before

Cavities have been insulated but are still exposed.



 After

After all accessible cavities have been air sealed and insulated, replace sheathing and siding to cover insulation.

Tools:

1. claw hammer
2. drill
3. mechanical fasteners

Materials:

1. OSB/Plywood(where existing)
2. Vinyl Soffit(where existing)

4.1301.8c

Desired Outcome:

Consistent, uniform thermal barrier between conditioned and unconditioned space to prescribed R-value of an adjoining insulated assembly

Specification(s):

Dense pack insulation will be installed between air barrier and subfloor according to manufacturer specifications

Insulation will be installed to prescribed R-value

Objective(s):

Insulate to prescribed R-value

Tools:

1. Insulation machine
2. Caulk gun

Materials:

1. Dense packable insulation
2. Caulk



Once rigid barrier has been sealed, insulation can be blown in



Rigid barrier should be sealed after insulating to maintain air barrier

4.1402.2a

Desired Outcome:

Basement insulation improves thermal performance and ensures sufficient drying potential

Specification(s):

Regional IECC will be followed for required R-values

Objective(s):

Improve thermal performance of the basement and living space

	Continuous Rigid Insulation, Interior or Exterior	Interior Cavity Insulation
Zone 1	0	0
Zone 2	0	0
Zone 3	5	13
Zone 4, except marine	10	13
Zone 5 and marine 4	15	19
Zone 6-8	16	19

Best Practice

Find your regional zone and insulation application to determine r-value

4.1402.2b

Desired Outcome:

Basement insulation improves thermal performance and ensures sufficient drying potential

Specification(s):

A continuous air barrier will be installed on the warm side of the insulation

Objective(s):

Prevent condensation on the basement wall

Tools:

1. Utility knife
2. Tape measure
3. Drill
4. Taping knife

Materials:

1. XPS insulation board
2. Kraft-faced fiberglass batts
3. Drywall
4. Spackle
5. Seam tape
6. Fasteners



Basement shows no sign of ground water penetration, but needs insulation



Insulation and drywall create an air barrier

4.1402.2b - Air barrier



XPS insulation board is a non-absorbent insulation option



The drywall still provides an air barrier to keep moisture build up on wall

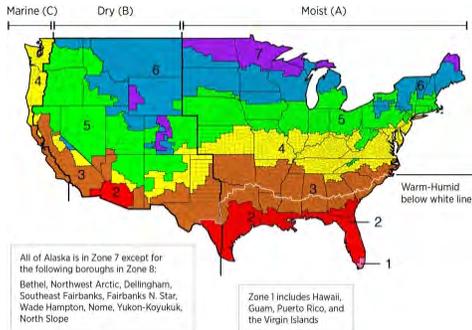


OR Kraft-faced fiberglass batts can be used with paper toward living space

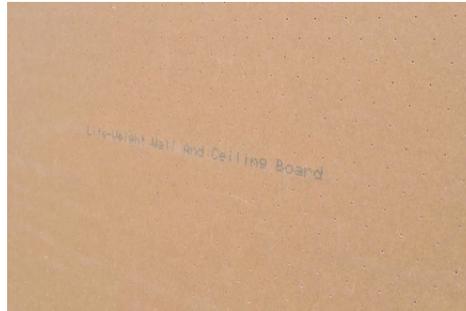


Both kraft-face and drywall create air barrier, but batts are absorbent

4.1402.2c - Vapor permeability



Determine in which zone you are working before selecting work materials



Many light-weight drywall brands have higher perm ratings for humid zones



In zones 7&8, vapor permeability is undesirable. Use a vapor retarder

4.1601.2a

Desired Outcome:

Lowered thermal conductance of duct system and minimized condensation on the duct system

Specification(s):

Duct insulation on all ducts located in unconditioned spaces will be a minimum of R-8, in accordance with local code, or buried under attic insulation, whichever is greater, and have an attached vapor retarder

Hot humid and warm coastal regions will not bury ducts

Objective(s):

Decrease heat loss and condensation problems



 Before

Uninsulated ducts in unconditioned spaces are an energy drain



 After

Properly insulated ducts operate at much higher rates of efficiency

4.1601.2d; 6.6002.1b

4.1601.2c

Desired Outcome:

Lowered thermal conductance of duct system and minimized condensation on the duct system

Specification(s):

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

Objective(s):

Ensure a secure connection between the duct system and the duct insulation

Tools:

1. Scissors
2. Metal snips

Materials:

1. Nylon twine
2. Wire
3. Tie bands



Before

Materials holding insulation in place should not compress or kink duct



After

Durable materials can be attached without compressing insulation

6.6002.1c

5.3003.1a

Desired Outcome:

Data for commissioning and future service work is recorded

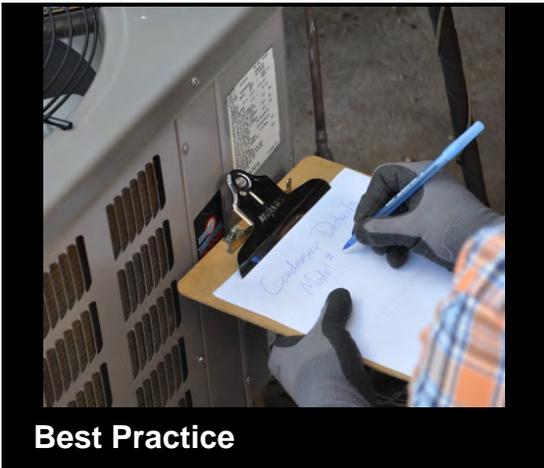
Specification(s):

Equipment will be visually inspected

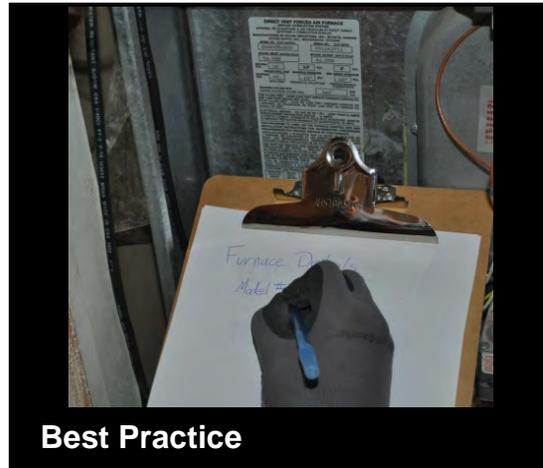
Information will be recorded from the equipment data plates indoors and outdoors

Objective(s):

Ensure technician has equipment data necessary for commissioning and future service work



Complete a visual inspection of all heating and cooling equipment



Record model information about heating and cooling equipment to ensure proper maintenance

5.3003.2b

Desired Outcome:

Analysis on critical components and operations completed in accordance with industry and manufacturer specifications

Specification(s):

Nozzle size will be correct for design input and within equipment firing rate of the heating system manufacturer

Objective(s):

Ensure equipment operates as designed

Ensure equipment operates safely

Ensure equipment operates efficiently

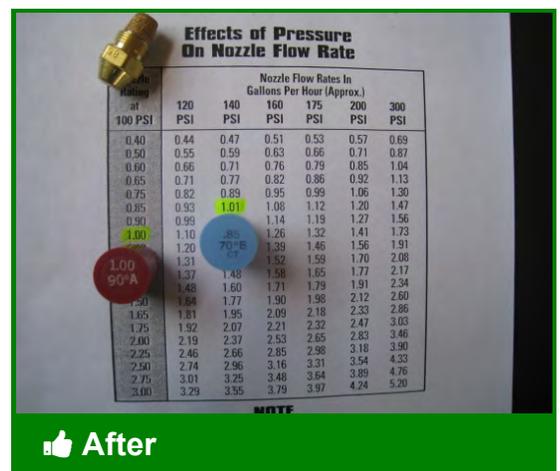
Ensure equipment is durable

Tools:

1. Calipers



Locate nozzles on oil-fired water heaters and furnaces



After

Verify that nozzle size is appropriate for model by consulting flow chart

5.3003.2c

Desired Outcome:

Analysis on critical components and operations completed in accordance with industry and manufacturer specifications

Specification(s):

Measurement will be verified in accordance with manufacturer specifications

Objective(s):

Ensure equipment operates as designed

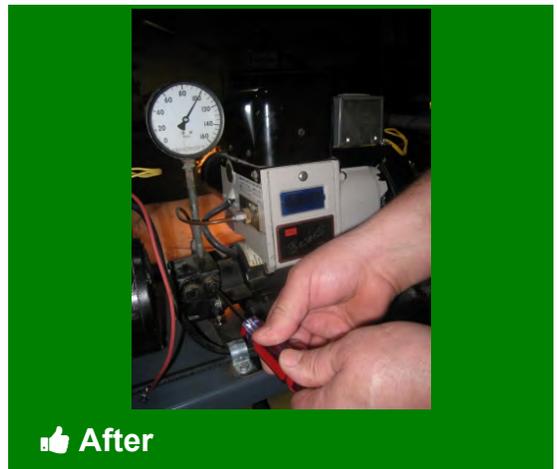
Ensure equipment operates safely

Ensure equipment operates efficiently

Ensure equipment is durable



Check oil-fired furnaces and water heaters for proper fuel pressure



👍 After

Verify that fuel pressure matches manufacturer's specifications

5.3003.2e

Desired Outcome:

Analysis on critical components and operations completed in accordance with industry and manufacturer specifications

Specification(s):

Smoke spot reading will be in accordance with burner manufacturer specifications

If smoke test is more than actionable levels, specify a clean and tune

Objective(s):

Ensure equipment operates as designed

Ensure equipment operates safely

Ensure equipment operates efficiently

Ensure equipment is durable

Tools:

1. Smoke testing pump

Materials:

1. Filter paper



Verify oil-fired furnaces and water heaters are operating safely



Best Practice

Smoke tests determine if oil-fired appliances burn cleanly by testing soot

5.3003.2f

Desired Outcome:

Analysis on critical components and operations completed in accordance with industry and manufacturer specifications

Specification(s):

Measurement will be verified in accordance with manufacturer specifications

Objective(s):

Ensure equipment operates as designed

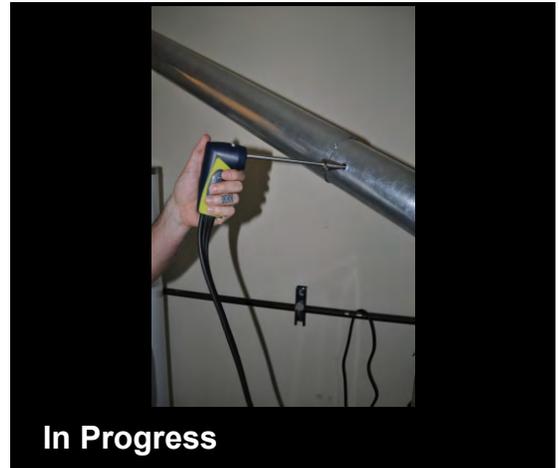
Ensure equipment operates safely

Ensure equipment operates efficiently

Ensure equipment is durable

Tools:

1. Combustion analyzer with probe



In Progress

Test flue gases to determine steady state efficiency



After

At steady state, this furnace tests at 83%-- within manufacturer tolerances

5.3003.2g

Desired Outcome:

Analysis on critical components and operations completed in accordance with industry and manufacturer specifications

Specification(s):

Net stack temperature will be measured and verified in accordance with manufacturer specifications

Objective(s):

Ensure equipment operates as designed

Ensure equipment operates safely

Ensure equipment operates efficiently

Ensure equipment is durable

Tools:

1. Combustion analyzer with probe



Verify oil-fired appliances are not burning hotter than manufacturer specs



T-stack minus T-air equals net stack temperature. Check against specs

T=temperature. T-stack minus T-air = Delta T or Net Stack Temperature.

5.3003.2h

Desired Outcome:

Analysis on critical components and operations completed in accordance with industry and manufacturer specifications

Specification(s):

Measurement will be verified in accordance with industry manuals and manufacturer specifications

Objective(s):

Ensure equipment operates as designed

Ensure equipment operates safely

Ensure equipment operates efficiently

Ensure equipment is durable

Tools:

1. Combustion analyzer with probe
2. Drill



In Progress

Verify oil-fired appliances are burning safely by testing CO2 and O2 levels



After

Levels should be within industry standards and match manufacturer specs

15.4% should be the highest allowable level of CO2 produced by an oil-fired appliance.

O₂ levels in the atmosphere are at a constant 20.9%. O₂ readings in appliances vary due to O₂ density and the efficiency of the combustion process.

5.3003.2i

Desired Outcome:

Analysis on critical components and operations completed in accordance with industry and manufacturer specifications

Specification(s):

Excess air will be calculated and shown to be in accordance with manufacturer specifications

Objective(s):

Ensure equipment operates as designed

Ensure equipment operates safely

Ensure equipment operates efficiently

Ensure equipment is durable

Tools:

1. Combustion analyzer with probe
2. Drill



Oil-fired appliances require an appropriate level of air mixed with the oil



The percentage of Excess Air (EA) should be within manufacturer specs

5.3003.2j

Desired Outcome:

Analysis on critical components and operations completed in accordance with industry and manufacturer specifications

Specification(s):

Undiluted flue gases will be checked with a calibrated combustion analyzer

If CO levels exceed levels in the chart below, service will be provided to reduce CO to below these levels (unless CO measurement is within manufacturer specifications)

Objective(s):

Ensure equipment operates as designed

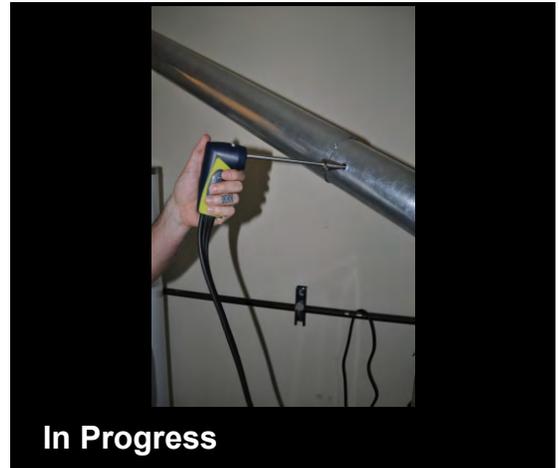
Ensure equipment operates safely

Ensure equipment operates efficiently

Ensure equipment is durable

Tools:

1. Combustion analyzer with probe
2. Drill



In Progress

Test oil-fired appliances for CO in the flue gases to verify safe levels



After

CO should measure less than 200ppm

CO Thresholds for Fossil-Fuel Fired Combustion Appliances Appliance

	Threshold Limit
Central Furnace (all categories)	400 ppm air free
Boiler	400 ppm air free
Floor Furnace	400 ppm air free
Gravity Furnace	400 ppm air free
Wall Furnace (BIV)	200 ppm air free
Wall Furnace (Direct Vent)	400 ppm air free
Vented Room Heater	200 ppm air free
Unvented Room Heater	200 ppm air free
Water Heater	200 ppm air free

5.3003.3h

Desired Outcome:

Air flow is properly tested

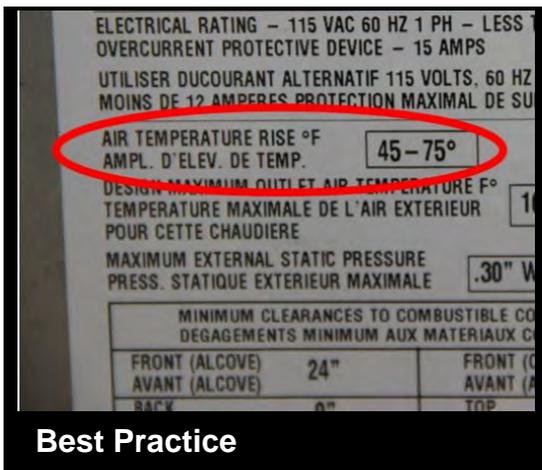
Specification(s):

Temperature rise between the supply and return will be in accordance with manufacturer specifications

Objective(s):

Ensure equipment:

- Operates as designed
- Operates efficiently
- Provides comfort
- Operates safely
- Is durable



Temperature rise should be within the range specified by the manufacturer. If it is not, airflow must be adjusted.

Tools:

1. thermometers

Supply temperature(out of line of sight of the heat exchanger) - return temperature = air temperature rise

e.g. $116.8 - 88.5 = 28.3$ which is well outside of the manufacturers recommendations of 45-75. Air speed adjustment is needed.

5.3003.10a

Desired Outcome:

Equipment and condensate drain operate as designed

Specification(s):

Connections in condensate drain system will be watertight

Objective(s):

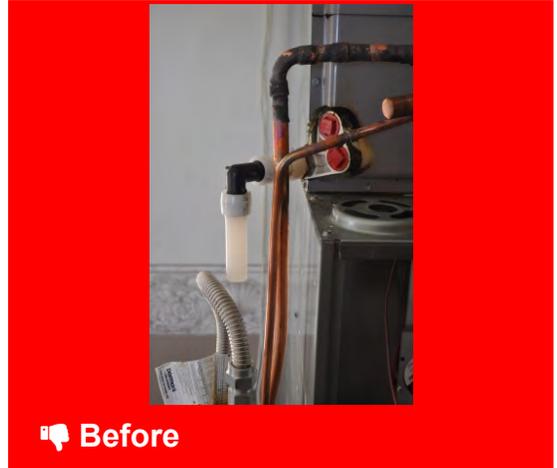
Ensure condensate drain connections do not leak

Tools:

1. Hacksaw
2. Crimper

Materials:

1. Pex piping and angles
2. PVC piping and angles
3. Purple primer



HVAC equipment needs condensate drainage to prevent water damage



Drainage pipes should be sealed to be water-tight

5.3003.10b

Desired Outcome:

Equipment and condensate drain operate as designed

Specification(s):

Condensate drainlines will be insulated with a minimum 1" of insulation with a vapor retarder when there is potential for condensation or freezing on the drainline

Objective(s):

Ensure condensate drain connections do not leak

Tools:

1. Tape measure
2. Utility knife

Materials:

1. 1" thick pipe insulation
2. Zip ties



 Before

Once drainage pipes cross into unconditioned space, they can freeze



 After

Pipes in unconditioned spaces should be insulated with 1" pipe insulation

5.3003.10c

Desired Outcome:

Equipment and condensate drain operate as designed

Specification(s):

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

Objective(s):

Ensure condensate drain connections do not leak



A float switch should be installed to prevent overflow and damage

5.3003.10g

5.3003.10d

Desired Outcome:

Equipment and condensate drain operate as designed

Specification(s):

Condensate drain pumps will be installed when condensate cannot be drained by gravity

Power source for pump will be installed

Operation and drainage of pump will be verified

Objective(s):

Ensure condensate drain connections do not leak



 **Before**

HVAC equipment that drains upward through a roof cannot drain naturally



 **After**

For non-gravity draining systems, a pump is necessary

5.3003.11a

Desired Outcome:

Heating and cooling controls installed and set properly

Specification(s):

Mercury-based thermostat will be removed safely and disposed of in accordance with EPA regulations

Objective(s):

Protect workers and occupants from injury

Protect environment from damage



Mercury thermostats should be replaced and disposed of properly



Do NOT dispose of mercury thermostats in the trash--find local recycling

Paraphrased from 40 CFR 273.14: A universal waste mercury-containing thermostat or container containing only universal waste mercury-containing thermostats should be labeled or marked clearly with any of the following phrases: "Universal Waste-Mercury Thermostat(s)," "Waste Mercury Thermostat(s)," or "Used Mercury Thermostat(s)." **Contact thermostat-recycle.org or earth911.org for recycling options.

5.3003.14a

Desired Outcome:

Analysis of critical components and operations completed in accordance with industry and manufacturer specifications

Specification(s):

Heating equipment will be placed in operation in accordance with applicable NFPA standards and manufacturer specifications when available

Objective(s):

Ensure equipment:

- Operates as designed
- Operates safely
- Operates efficiently
- Is durable



 Before

Appliance is set to OFF at the electrical disconnect, and will not fire.



 After

Appliance is set to ON at the disconnect, and can now fire.

Ensure appliance is fired in accordance with manufacturer specifications.

5.3003.14a - Place appliance in operation



Propane - Ensure gas valve is open at the tank and there is fuel in the tank.



Natural Gas - Ensure the valve on the meter is on.



Ensure gas valve is open at the appliance.



Turn appliance to heat, and raise the the temperature 15 degrees above ambient conditions.

5.3003.14c

Desired Outcome:

Analysis of critical components and operations completed in accordance with industry and manufacturer specifications

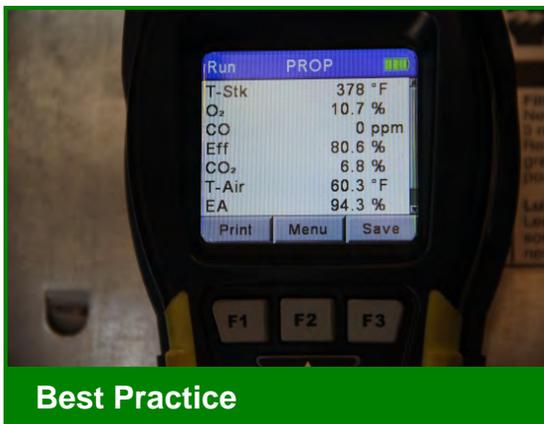
Specification(s):

Measurement will be verified in accordance with industry manuals (e.g., Testo, Bacharach)

Objective(s):

Ensure equipment:

- Operates as designed
- Operates safely
- Operates efficiently
- Is durable



Best Practice

Carbon dioxide and oxygen levels should be measured in undiluted flue gas

Tools:

1. Combustion analyzer with probe

Oxygen levels should usually fall between 7 - 9%. CO₂ should be between 6.5 - 8%.

5.3003.14e

Desired Outcome:

Analysis of critical components and operations completed in accordance with industry and manufacturer specifications

Specification(s):

CO in the undiluted flue gas will be less than 100 ppm

Objective(s):

Ensure equipment:

- Operates as designed
- Operates safely
- Operates efficiently
- Is durable



Best Practice

CO levels should be less than 100 ppm to ensure safe operation

5.3003.14f

Desired Outcome:

Analysis of critical components and operations completed in accordance with industry and manufacturer specifications

Specification(s):

All testing and inspection holes will be sealed with manufacturer approved materials

Objective(s):

Ensure equipment:

- Operates as designed
- Operates safely
- Operates efficiently
- Is durable

Materials:

1. high temperature sealant

6.6002.1a

Desired Outcome:

Installed ducts effectively move the required volume of air and prevent condensation

Specification(s):

Ventilation ducts will be as short, straight, and smooth as possible

Ventilation ducts will not be smaller than the connections to which they are attached

Objective(s):

Effectively move the required volume of air

Tools:

1. Metal snips
2. Drill

Materials:

1. Metal duct piping
2. Fasteners



Duct work for exhaust fans should be short, smooth, and not pinch down



Duct is the same size as the outlet and makes shortest run possible

See also ASHRAE 62.2-2013.

6.6002.1d

Desired Outcome:

Installed ducts effectively move the required volume of air and prevent condensation

Specification(s):

Round metal-to-metal or metal-to-PVC will be fastened with a minimum of three equally spaced screws

Other metal-to-metal or metal-to-PVC connections will be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic- plus-embedded-fabric systems, or tapes

Flexible duct-to-metal or flexible duct-to-PVC will be fastened with tie bands using a tie band tensioning tool

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

Other specialized duct fittings will be fastened in accordance with manufacturer specifications

In addition to mechanical fasteners, duct connections will be sealed with UL 181B or 181B-M listed material

Objective(s):

Effectively move the required volume of air

Preserve the integrity of the duct system



Before
Fan duct is disconnected and venting into the attic space.



After
Fan has been vented with sealed, insulated duct material.

Tools:

1. drill
2. tie band tensioner
3. brush

Materials:

1. tie bands
2. insulated flex duct
3. mastic
4. PVC primer
5. PVC cement

6.6002.1d - Duct connections



Apply mastic to the connection fitting.



Snug duct liner onto connection fitting.



Use zip tie and tensioner to secure liner to connection fitting.



Apply mastic to fan connection.



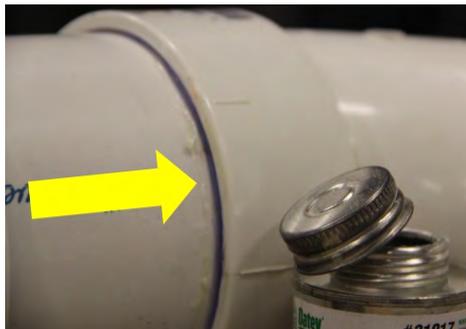
Using mechanical fasteners, secure connection fitting to fan connection.



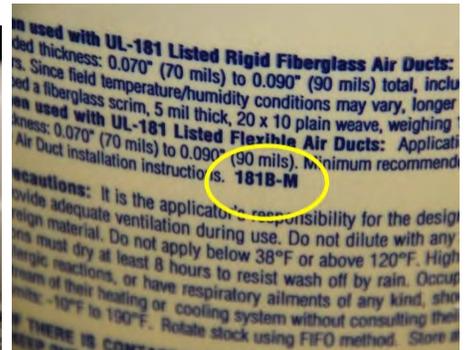
Snug insulation to fan housing and strap into place.



Round metal-to-metal connections require fiberglass mesh tape and 3 mechanical fasteners minimum.



PVC-to-PVC connections should use PVC primer and cement.



Sealants should show UL181-M or UL181B-M.

6.6002.1e

Desired Outcome:

Installed ducts effectively move the required volume of air and prevent condensation

Specification(s):

Flexible materials will be UL 181 listed or Air Diffusion Council approved

Rigid, kitchen fans gauges shall meet code requirements or authority having jurisdiction

Objective(s):

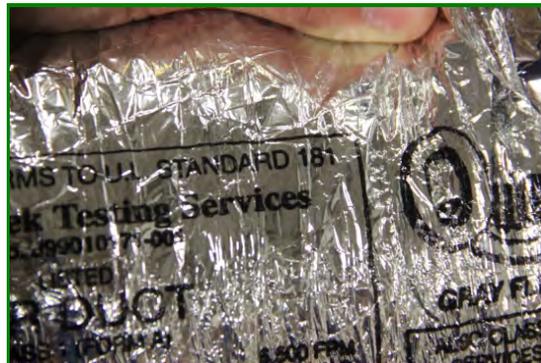
Effectively move the required volume of air

Preserve the integrity of the duct system



Bad Practice

Existing duct is installed incorrectly and is not UL listed



Best Practice

This flexible duct conforms to UL 181

Materials:

1. All materials should be UL 181 Listed
2. 30-gauge minimum Rigid Duct

6.6002.2a

Desired Outcome:

Securely installed termination fittings with unrestricted air flow

Specification(s):

A hole no greater than a 1/4" greater than the fitting will be cut to accommodate termination fitting

Objective(s):

Allow for ease of weatherproofing

Tools:

1. Hole saw
2. Drill
3. Tape measure



Exhaust fans need exterior ventilation, often through roofs and walls



Hole should be no more than 1/4" larger than termination fitting diameter

6.6002.2b

Desired Outcome:

Securely installed termination fittings with unrestricted air flow

Specification(s):

A termination fitting with an integrated collar will be used

Collar will be at least the same diameter as the exhaust fan outlet; if collar is larger than exhaust fan outlet, a rigid metal transition will be used

Fitting will be appropriate for regional weather conditions and installation location on house so as not to be rendered inoperable

Objective(s):

Effectively move the required volume of air to the outside

Preserve integrity of the building envelope

Ensure durable installation

Tools:

1. Drill

Materials:

1. Fasteners



Before

Termination fittings with no collar are to be avoided



After

Properly sized ducts with snug connections to collared fittings last longer

6.6002.2c

Desired Outcome:

Securely installed termination fittings with unrestricted air flow

Specification(s):

Duct will be connected and sealed to termination fitting as follows:

- Round metal-to-metal or metal-to-PVC will be fastened with a minimum of three equally spaced screws
- Other metal-to-metal or metal-to-PVC connections will be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, or tapes
- Flexible duct-to-metal or flexible duct-to-PVC will be fastened with tie bands using a tie band tensioning tool
- PVC-to-PVC materials will be fastened with approved PVC cement
- Other specialized duct fittings will be fastened in accordance with manufacturer specifications
- In addition to mechanical fasteners, duct connections will be sealed with UL 181B or 181B-M listed material

Fasteners will not inhibit damper operation

Objective(s):

Effectively move the required volume of air to the outside

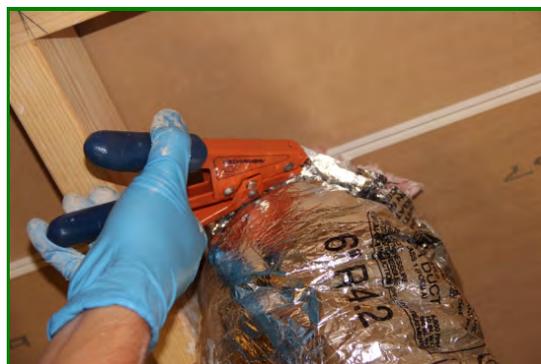
Preserve integrity of the building envelope

Ensure durable installation



 Before

Termination is not mechanically fastened, or sealed appropriately.



 After

Termination fitting is secure, and duct is sealed to termination.

6.6002.2d

Desired Outcome:

Securely installed termination fittings with unrestricted air flow

Specification(s):

Exterior termination fitting will be flashed or weather sealed

Water will be directed away from penetration

Installation will not inhibit damper operation

Manufacturer specifications will be followed

Objective(s):

Preserve integrity of the building envelope

Ensure a weather tight and durable termination installation

Ensure unrestricted air flow

Tools:

1. Hole saw
2. Caulk gun
3. Drill

Materials:

1. Fasteners
2. Caulk



Before

Holes for termination fitting need to be sealed to weatherproof



After

Termination installation should follow shingling to deter water penetration

6.6002.2e

Desired Outcome:

Securely installed termination fittings with unrestricted air flow

Specification(s):

Screen material with no less than 1/4" and no greater than 1/2" hole size in any direction will be used

Installation will not inhibit damper operation or restrict air flow

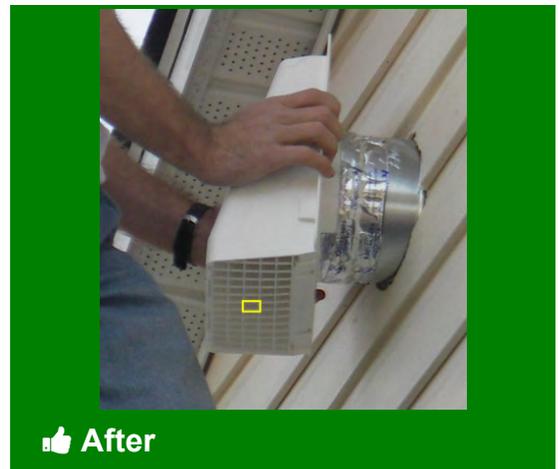
Objective(s):

Prevent pest entry

Ensure proper air flow



Exhaust terminations without screens are an invitation to pest intrusion



Screen mesh should be between 1/4" and 1/2" in either direction

6.6002.2f

Desired Outcome:

Securely installed termination fittings with unrestricted air flow

Specification(s):

Terminations will be ducted to the outdoors, which does not include unconditioned spaces such as attics and crawl spaces that are ventilated with the outdoors.

Terminations will be installed:

- A minimum of 3' away from any property line
- A minimum of 3' away from operable opening to houses
- A minimum of 10' away from mechanical intake
- As required by authority having jurisdiction

Objective(s):

Prevent exhaust from reentering house

Tools:

1. Measuring tape
2. Hole saw
3. Drill



Exhaust vent has been improperly mounted too close to mechanical vent



Exhaust vent was properly mounted over 3ft from door, window, and deed line

6.6002.2g

Desired Outcome:

Securely installed termination fittings with unrestricted air flow

Specification(s):

Galvanized steel, stainless steel, or copper will be used for termination fitting for kitchen exhaust

Objective(s):

Prevent a fire hazard



Kitchen exhaust vents should not be made from highly combustible materials



This roof-mounted kitchen exhaust fan is galvanized steel--heat resistant

6.6003.3a

Desired Outcome:

Through the wall fans installed to specification

Specification(s):

A hole no greater than a 1/4 inch greater than the assembly will be cut to accommodate fan assembly

Objective(s):

Allow for ease of weatherproofing



 Before

Determine size to cut hole by measuring fan assembly and ducting



 After

A snug fit should be ensured to minimize weatherproofing required

Tools:

1. Tape measure
2. Saw

6.6003.3b

Desired Outcome:

Through the wall fans installed to specification

Specification(s):

Wiring will be installed in accordance with original equipment manufacturer specifications, and local and national electrical and mechanical codes

Objective(s):

Prevent an electrical hazard



👎 Before

Incorrect: disconnected ground, no wire nuts on splices, no clamp on wires passing through junction box



👍 After

Fan junction box with cover installed

Tools:

1. Wire strippers
2. Utility knife or cable ripper
3. Screwdriver
4. Non-contact voltage tester
5. Lineman's pliers

Materials:

1. Ground wire crimp sleeves
2. Non-metallic sheathed wire (Type NM-B) e.g., Romex ®
3. Plastic junction box and cover plate
4. Wire nuts
5. Cable staples
6. Clamp-type cable connectors

Follow manufacturer's specifications and applicable codes when wiring newly installed equipment.

6.6003.3c

Desired Outcome:

Through the wall fans installed to specification

Specification(s):

Fan outlet will be oriented toward the final termination location

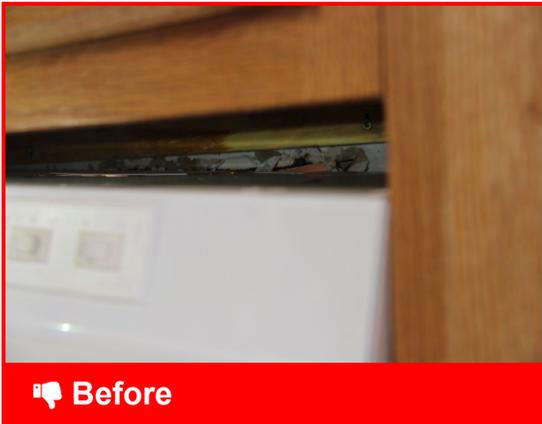
Fan will be oriented so the equivalent length of the duct run is as short as possible

Fan will be mounted securely according to manufacturer specifications

Objective(s):

Install mounting fan securely

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



Improperly aligned fan



Fan is mounted securely with the termination outlet lined up.

Tools:

1. drill
2. drill bits

Materials:

1. fasteners

6.6003.3d

Desired Outcome:

Through the wall fans installed to specification

Specification(s):

Exterior termination fitting will be flashed or weather sealed

Water will be directed away from penetration

Termination fitting installation will not inhibit damper operation

Manufacturer specifications will be followed

Objective(s):

Preserve integrity of the building envelope

Ensure a weather tight and durable installation

Ensure unrestricted air flow



Best Practice

Apply sealant behind termination cap, taking care to apply sealant to all edges.



Best Practice

Termination is sealed and securely attached to the wall.

Tools:

1. caulk gun
2. drill
3. drill bits
4. reciprocating saw
5. drywall saw or utility knife

Materials:

1. weatherproof termination kit with pest screen
2. caulk or equivalent sealant
3. mechanical fasteners

6.6003.3e

Desired Outcome:

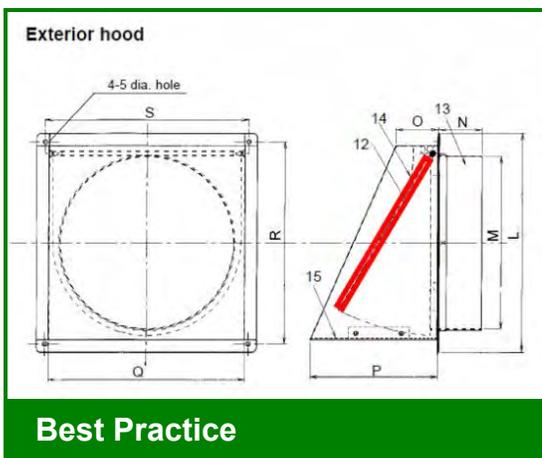
Through the wall fans installed to specification

Specification(s):

A backdraft damper will be installed between the outlet side of the fan and the exterior

Objective(s):

Prevent reverse air flow when the fan is off



Damper should be installed to maintain exterior air barrier

6.6003.3f

Desired Outcome:

Through the wall fans installed to specification

Specification(s):

Sealants will be compatible with their intended surfaces

Sealants will be continuous and meet fire barrier specifications

Objective(s):

Prevent air leakage through fan housing

Ensure a permanent seal to the building air barrier



Sealant should be waterproof and adhere to the desired surfaces.



Seal unused holes in the fan housing.

Tools:

1. caulk gun

Materials:

1. weatherproof, code approved caulk

6.6003.3g

Desired Outcome:

Through the wall fans installed to specification

Specification(s):

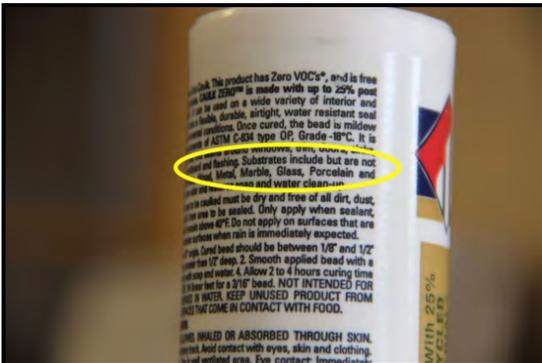
Sealants will be compatible with their intended surfaces

Sealants will be continuous and meet fire barrier specifications

Objective(s):

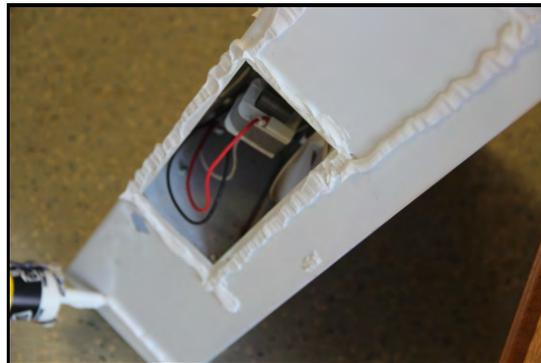
Prevent air leakage around intake housing

Prevent a fire hazard



Best Practice

Sealant should be waterproof and adhere to desired surfaces.



Best Practice

Sealant should be applied to the fan housing where it comes in contact with the exterior wall.

Tools:

1. caulk gun

Materials:

1. code approved caulk

6.6003.3i

Desired Outcome:

Through the wall fans installed to specification

Specification(s):

Air flows in CFM will be measured and adjusted to meet the design requirements

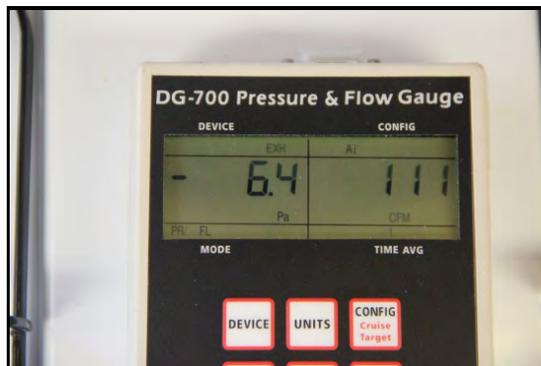
Objective(s):

Exhaust sufficient air from desired locations to outside



Best Practice

Using a digital manometer, exhaust flow meter and fabricated cover, measure the fan flow.



Best Practice

Air flow should be within acceptable limits for the location of the fan.

Tools:

1. exhaust fan flow meter
2. manometer

Materials:

1. a fabricated cover for fans larger than the flow meter

6.6003.3i - Air flow



1 The exhaust fan flow meter won't fit most range hoods. A fabricated cover is needed.



2 A fabricated cover can be used so long as the opening is smaller than the meter itself and larger than the E1 opening.



3 Attach a pressure hose to the exhaust fan flow meter.



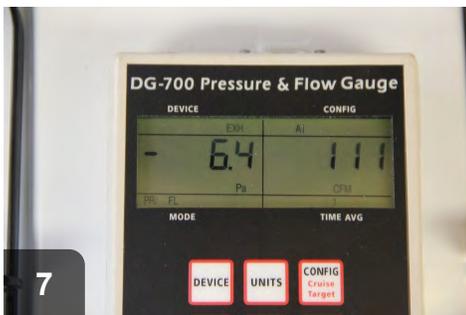
4 Attach a the hose to a T connection on channels A & B with the manometer set to measure exhaust fan flow.



5 With manometer properly set up, prepare to test air flow



Fans must pull the required CFM according to ASHRAE.



7 With the manometer Mode set to PR/FL, Device set to EXH, and Config set to E1, this fan pulls 111 CFM.

6.6003.3k

Desired Outcome:

Through the wall fans installed to specification

Specification(s):

Pressure effects caused by fans will be assessed and corrected when found outside of combustion safety standards

Make-up air will be provided in accordance with the current version of ASHRAE 62.2 and in compliance with the authority having jurisdiction.

Objective(s):

Ensure safe operation of combustion appliances

Tools:

1. Manometer



Installing new ventilation can cause imbalances within the house



Test that depressurization limit is not being exceeded by new ventilation

See SWS 2.0299.1a-i for CAZ depressurization limits

6.6005.1a

Desired Outcome:

Dryer air exhausted efficiently and safely

Specification(s):

Clothes dryers will be ducted to the outdoors, which does not include unconditioned spaces such as attics and crawl spaces that are ventilated with the outdoors

As short a run as practical of rigid sheet metal or semi-rigid sheet metal venting material will be used in accordance with manufacturer specifications

Dryer ducts exceeding 35' in duct equivalent length will have a dryer booster fan installed

Plastic venting material will not be used

Uninsulated clothes dryer duct will not pass through unconditioned spaces such as attics and crawl spaces

Ducts will be connected and sealed as follows:

- UL listed foil type or semi-rigid sheet metal to rigid metal will be fastened with clamp
- Other specialized duct fittings will be fastened in accordance with manufacturer specifications
- In addition to mechanical fasteners, duct connections will be sealed with UL 181B or 181B-M listed material

In addition:

- Sheet metal screws or other fasteners that will obstruct the exhaust flow will not be used
- Condensing dryers will be plumbed to a drain

Objective(s):

Preserve integrity of building envelope

Effectively move air from clothes dryer to outside



 **Before**

Dryer is vented outside, but with the incorrect material.



 **After**

Dryer is vented outdoors, with correct material. Run is as short and straight as possible ensuring maximum flow.

Tools:

1. metal trimmers
2. drill

Materials:

1. metal flex duct
2. dryer vent kit
3. hose clamps

6.6005.1b

Desired Outcome:

Dryer air exhausted efficiently and safely

Specification(s):

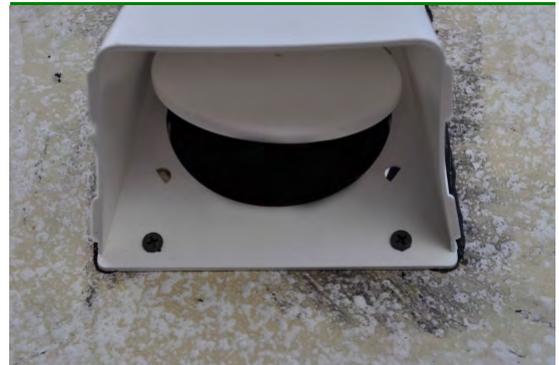
Termination fitting manufactured for use with dryers will be installed

A backdraft damper will be included, as described in termination fitting detail

Objective(s):

Preserve integrity of building envelope

Effectively move air from clothes dryer to outside



Best Practice

Termination fittings for dryers should have backdraft dampers

6.6005.1d

Desired Outcome:

Dryer air exhausted efficiently and safely

Specification(s):

Pressure effects caused by fans will be assessed and corrected when found outside of combustion safety standards

Objective(s):

Ensure safe operation of combustion appliances

Ensure occupant health and safety

Tools:

1. Manometer



Appliance exhaust, such as that for a dryer, can cause depressurization



Test to verify combustion appliances are within depressurization limits

See SWS 2.0299.1a-i for CAZ depressurization limits

6.6005.1e

Desired Outcome:

Dryer air exhausted efficiently and safely

Specification(s):

Occupant will be instructed to keep lint filter and termination fitting clean

Occupant will be instructed to keep dryer booster fan clean, if present

Occupant will be instructed on clothes dryer operation safety including information on items that must not be placed in the clothes dryer (items with any oil or other flammable liquid on it, foam, rubber, plastic or other heat-sensitive fabric, glass fiber materials)

Objective(s):

Effectively move air from clothes dryer to outside



Neglect of clothes dryer maintenance can cause fire hazards



Occupants should be taught to clean lint filters and termination fittings

6.6005.1e - Occupant education



In homes with booster fans, occupant should know location and how to clean



Occupants should be taught never to put flammable articles in dryer (in this case, oily rags)

6.6005.2b

Desired Outcome:

Kitchen range fan installed to specification

Specification(s):

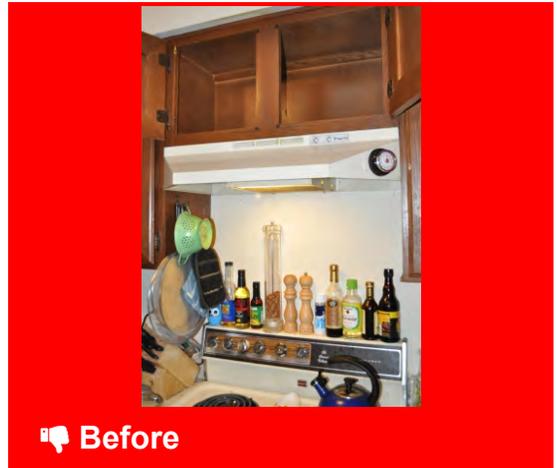
Kitchen range fans will be vented to the outdoors

Recirculating fans will not be used as a ventilating device

Objective(s):

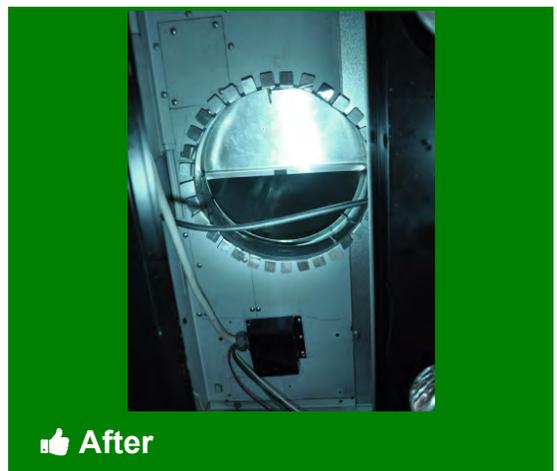
Remove cooking contaminants from the house

Preserve integrity of building envelope



Before

Recirculating fans over ranges do not actually remove contaminants



After

Daylight visible through dampered kitchen exhaust proves venting access

6.6005.2c

Desired Outcome:

Kitchen range fan installed to specification

Specification(s):

Kitchen range fans will be ducted to the outdoors

As short a run as practical of smooth wall metal duct will be used, following manufacturer specifications

Ducting will be connected and sealed as follows:

- Metal-to-metal will be fastened with a minimum of three equally spaced screws
- Other metal-to-metal connections will be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, or tapes
- For down-draft exhaust systems, PVC-to-PVC materials will be fastened with approved PVC cement
- Other specialized duct fittings will be fastened in accordance with manufacturer specifications
- In addition to mechanical fasteners, duct connections will be sealed with UL 181B or 181B-M listed material

Objective(s):

Preserve integrity of building envelope

Effectively move air from range to outside

Tools:

1. Drill
2. Putty knife
3. Tape measure
4. Metal snips
5. Saw

Materials:

1. Round metal ducting
2. Mastic
3. Fiberglass mesh tape
4. Fasteners



Exhaust duct should be smooth-walled and in as short a run as possible



Daylight visible through dampered kitchen exhaust proves outside access

See also 6.6002.1d. Note: Only smooth-wall metal duct will be used, except for down-draft exhaust systems where PVC is acceptable as well. Flex duct is NOT acceptable for kitchen fan exhaust application.

6.6005.2d

Desired Outcome:

Kitchen range fan installed to specification

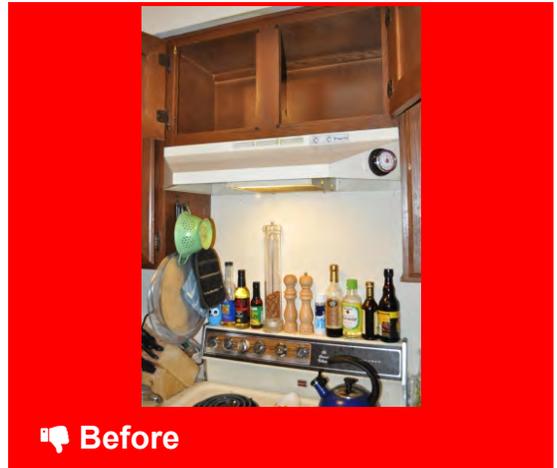
Specification(s):

Termination fitting will be installed including a backdraft damper, as described in termination fitting detail

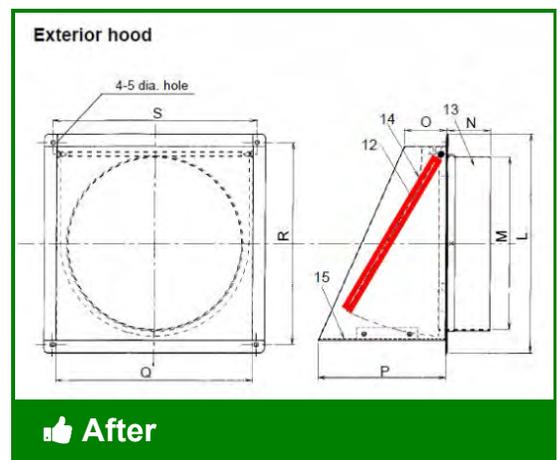
Objective(s):

Ensure safe operation of combustion appliances

Ensure occupant health and safety



Kitchen fans should exhaust to the exterior, not just recirculate air



Exhaust fans should have backdraft dampers

6.6005.2e

Desired Outcome:

Kitchen range fan installed to specification

Specification(s):

Make-up air will be provided in accordance with the current version of ASHRAE 62.2 and in compliance with the authority having jurisdiction

Objective(s):

Ensure safe operation of combustion appliances

Ensure occupant health and safety

Tools:

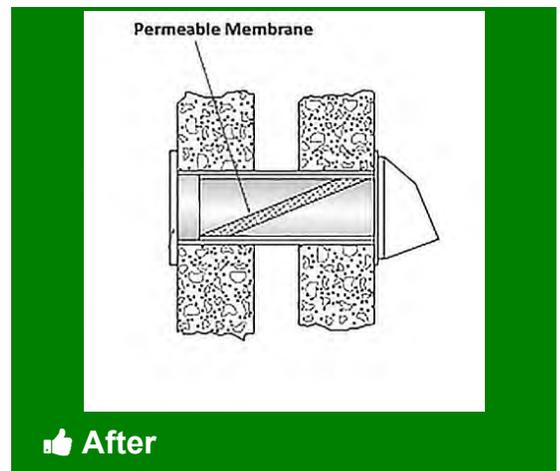
1. Drill
2. Hole saw
3. Caulk gun

Materials:

1. Caulk sealant
2. Fasteners



If kitchen exhaust is venting at more than 200 cfm, provide make-up air



A passive inlet vent can provide make-up air for kitchen exhaust

6.6005.2f

Desired Outcome:

Kitchen range fan installed to specification

Specification(s):

Pressure effects caused by fans will be assessed and corrected when found outside of combustion safety standards

Objective(s):

Ensure safe operation of combustion appliances

Ensure occupant health and safety

Tools:

1. Manometer



Kitchen exhaust fans can cause combustion appliances to depressurize



Test that combustion appliances are operating within depressurization limit

See SWS 2.0299.1a-i for CAZ depressurization limits

6.6201.2a

Desired Outcome:

Air circulates freely between rooms

Specification(s):

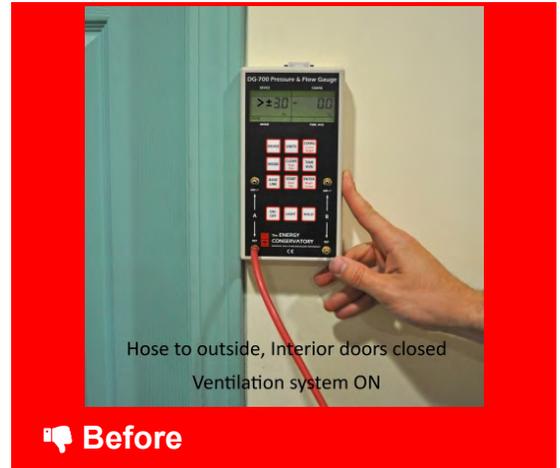
An appropriate means of pressure balancing will be installed (e.g., transfer grilles, jumper ducts, individual room returns)

No room will exceed +/- 3 pascals with reference to the outdoors with all interior doors closed and ventilation systems running

Objective(s):

Ensure free flow of air between rooms

Preserve integrity of the building envelope



If reading is >+/-3pa, interior ventilation needs to be installed

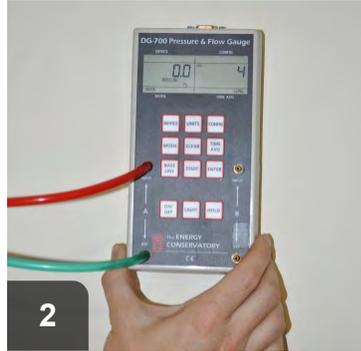


Passive door vents and individual room returns are two possibilities

6.6201.2a - Balancing pressure



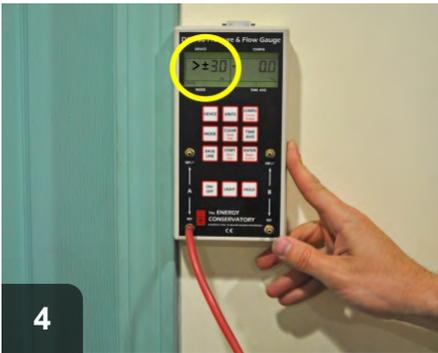
With interior doors open, put reference hose to exterior



Take baseline reading



Turn on exhaust fans and close interior doors



With hose under door, check pressure again. Readings $>+/-3pa$ are no good and require interior ventilation

7.8102.2e

Desired Outcome:

Safe and reliable hot water source provided that meets occupant needs at lowest possible cost of ownership

Specification(s):

A potable water expansion tank will be installed on the cold water side

A direct connection with no valves between the storage tank and expansion tank will be installed in accordance with the ND State Plumbing Code, authority having jurisdiction, and according to manufacturer specifications

Objective(s):

Protect the storage tank from expansion



Bad Practice

Need to eliminate the valves between the storage tank and expansion tank



Best Practice

GOOD: Expansion tank is installed on both cold sides

Appropriate licensing for installer required.

7.8102.2f

Desired Outcome:

Safe and reliable hot water source provided that meets occupant needs at lowest possible cost of ownership

Specification(s):

Correct temperature and pressure relief valve will be installed in compliance with the ND State Building Code and according to manufacturer specifications

Temperature and pressure relief valve discharge tube will be installed in accordance with the ND State Building Code

Objective(s):

Discharge excessive energy (pressure or temperature) from storage tank to safe location

Tools:

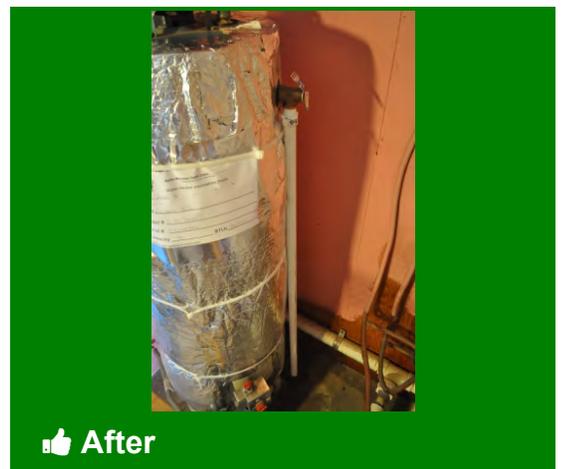
1. Pipe wrench
2. Hacksaw

Materials:

1. PVC
2. Plumber's epoxy



Water heaters should be not capped off at t&p valve



T&P discharge should be piped to a safe and observable location

Check local jurisdictional codes. Paraphrased from the ND State Building Code: Temperature and pressure relief valve discharge pipes should not be connected to drainage system. T&P discharge pipes should be a clean line without valve or tee, flowing with gravity to an observable and safe location that cannot cause personal injury or structural damage -- the floor, an existing drain pan, a waste receptor, or to the outdoors. Pipe should not terminate more than 6" from floor, pan or waste receptor.

7.8102.2f - Temperature and pressure relief valve



GOOD: T&P discharge should be piped within 6" of the floor or to outdoors



BAD: T&P discharge should flow with gravity and be observable



BAD: T&P discharge should not be piped into drainage system

7.8102.2k

Desired Outcome:

Safe and reliable hot water source provided that meets occupant needs at lowest possible cost of ownership

Specification(s):

Discharge temperature will be set not to exceed 120° or as prescribed by local code

Objective(s):

Ensure safe hot water supply temperature to fixtures

Tools:

1. Thermometer



Unsafe

Water heaters producing water over 120 degrees raise heating costs



Safe

Water heaters should produce water under 120 degrees to prevent scalding

7.8102.2k - Discharge temperature



1
Test temperature of hot water at faucets in house



2
Hot water temperatures should not exceed 120 degrees Fahrenheit



3
Adjust water heater settings and insulate as needed



4
After adjustment and insulation, retest to verify temp is under 120 degrees

7.8103.1a

Desired Outcome:

Safe, reliable, and efficient operation of the appliance maintained

Specification(s):

Combustion safety testing will be performed in accordance with the Health and Safety Chapter of the Standard Work Specifications for Single Family Housing or other equivalent practice

Electrical components will be verified to comply with the ND State Electrical Code (e.g., no electrical box connector, no disconnect, improperly sized breaker and wire)

Objective(s):

Identify potential health and safety issues

Tools:

1. Personal CO monitor
2. Combustion analyzer with probe
3. Manometer
4. Smoke pencil

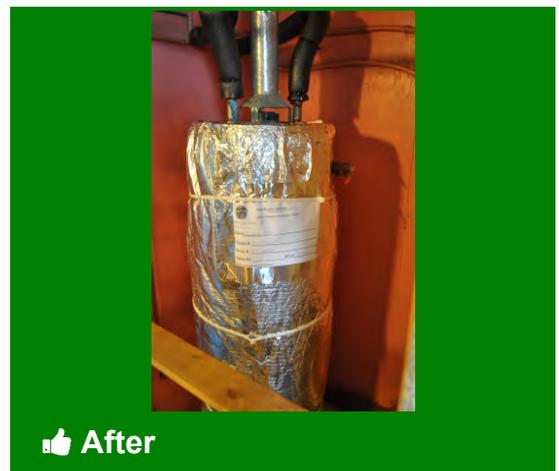
Materials:

1. CO alarm
2. Fasteners



Before

Complete combustion safety testing to ensure healthy, safe work environment



After

When completed work, retest to verify home is still healthy and safe

See also SWS 2.0201.1a-2.0299.1i for all Combustion Safety details and SWS 2.0100.1d for

General Electrical Safety.

7.8103.1c

Desired Outcome:

Safe, reliable, and efficient operation of the appliance maintained

Specification(s):

Water heater storage tanks shall have a minimum R-value of R-24, unless the SIR to add insulation is less than 1.0

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

The first 6' of inlet and outlet piping will be insulated in accordance with the ND State Building Code or local requirements, whichever is greater

Objective(s):

Reduce standby losses from near tank piping and storage tank

Ensure insulation does not make contact with flue gas venting

Tools:

1. Utility knife

Materials:

1. Pipe wrap
2. Water heater blanket
3. Foil tape
4. Long zip ties



Standard water heaters have built-in insulation ranging from R-7 to R-20.



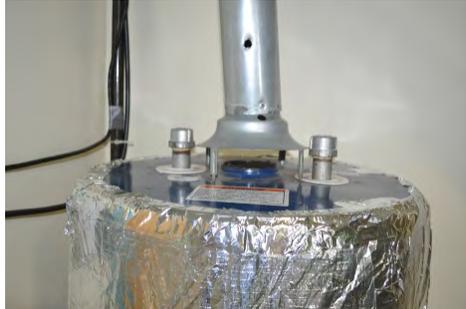
Best Practice

Storage-type water heaters should be wrapped to bring total value to R-24

7.8103.1c - Thermal efficiency



Check occupant's water heater model to see what r-value is built-in



Blanket does not obstruct draft diverter or plumbing pipes and elements



Wrap does not obstruct ventilation, thermostat access plate, hi-limit switch, or fuel line



Data plate should still be accessible after wrapping



Both hot and cold water pipes should be insulated to R-3 for first 6ft

7.8103.1e

Desired Outcome:

Safe, reliable, and efficient operation of the appliance maintained

Specification(s):

Correct temperature and pressure relief valve will be installed in compliance with the ND State Building Code and according to manufacturer specifications

Temperature and pressure relief valve discharge tube will be installed in accordance with the ND State Building Code

Objective(s):

Discharge excessive energy (pressure or temperature) from storage tank to safe location

Tools:

1. Pipe wrench
2. Hacksaw

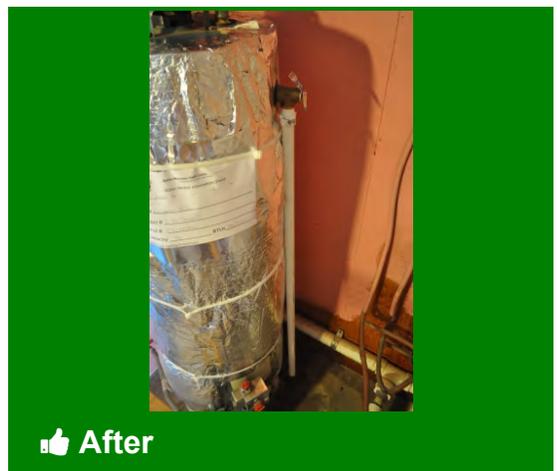
Materials:

1. PVC
2. Plumber's epoxy



Before

Water heaters should not be capped off at t&p valve



After

T&P discharge should be piped to a safe and observable location

Check local jurisdictional codes. Paraphrased from the ND State Building Code: Temperature and pressure relief valve discharge pipes should not be connected to drainage system. T&P discharge pipes should be a clean line without valve or tee, flowing with gravity to an observable and safe location that cannot cause personal injury or structural damage -- the floor, an existing drain pan, a waste receptor, or to the outdoors. Pipe should not terminate more than 6" from floor, pan or waste receptor.

7.8103.1e - Temperature and pressure relief valve



GOOD: T&P discharge should be piped within 6" of the floor or to outdoors



BAD: T&P discharge should flow with gravity and be observable



BAD: T&P discharge should not be piped into drainage system