

Retrofitting North Dakota



**Standard Work Specifications
and Field Guide**

for

Manufactured Housing

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



Unsafe

Recognize potential risks



Safe

Wear appropriate hand protection

2.0100.1b - Hand protection



GOOD: Wear nitrile gloves when handling mastic



Inspect gloves for holes and damage to minimize risk

2.0100.2c

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

Objective(s):

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



Unsafe

Workers need to properly protect their airways when retrofitting



Best Practice

Retrofits can have multiple different respiratory protection requirements

2.0100.2c - Respiratory protection



Whenever airborne contaminants are a possibility, wear an N-95 mask



For two-component spray insulation, P-100 respirators should be used



All P-100s should be fitted to the individual worker



When working with high-pressure spray foam, use a Supplied Air Respirator



When unsure what level of protection is necessary, check the SDS

2.0100.1d

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

If contaminants are present (e.g., insulation materials), removable protective clothing will be worn

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

Objective(s):

Protect worker from skin contact with contaminants

Minimize spread of contaminants

Provide eye protection



Bad Practice

This worker has donned some PPE, but is not fully protected.



Best Practice

The worker has donned proper PPE, and is fully protected.

Tools:

1. Safety Glasses or Goggles
2. Disposable Coverall
3. Gloves
4. Shoe Covers
5. Ear Plugs (situation-dependent)

2.0100.1d - Personal protective equipment (PPE)



Select the proper PPE according to the task to be performed. More volatile substances require more protection.

2.0100.1e

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

Spaces with limited ingress and egress and restricted work area will be considered confined space

Access and egress points will be located before beginning work

Inspection will be conducted for hazards, such as damaged or exposed electrical conductors, mold, sewage effluent, friable asbestos or fiberglass, pests, and other potential hazards

Adequate ventilation will be provided

Use of toxic material will be reduced

Objective(s):

Provide adequate access and egress points

Reduce risk to the workers in the confined space

Prevent buildup of toxic or flammable contaminants

Prevent electrical shock



Unsafe

Inspect confined spaces for safety concerns and hazards before work begins



Best Practice

Ensure proper personal protective equipment is worn and that workers are aware of ingress and egress points

Tools:

1. Flashlight
2. Ventilator

From OSHA.gov: "Many workplaces contain areas that are considered "confined spaces" because while they are not necessarily designed for people, they are large enough for workers to enter and perform certain jobs. A confined space also has limited or restricted means for entry or exit and is not designed for continuous occupancy."

<https://www.osha.gov/SLTC/confinedspaces/index.html>

2.0100.1e - Confined space safety



Spaces with limited ingress and egress will be considered confined



Locate all ingress and egress points before work begins



Inspect work space for hazards and safety concerns before work begins



Provide adequate ventilation



Check safety labels and avoid the use of toxic materials



Do NOT use hazardous materials in confined spaces -- particularly those carrying these GHS warnings

2.0100.1f

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

Power tools will be inspected and used in accordance with manufacturer specifications to eliminate hazards associated with missing ground prongs, ungrounded circuits, misuse of power tools, noise, and improper or defective cords or extension cords

All devices used will be verified as GFCI protected or double insulated

Exhaust gases from compressors and generators will be prevented from entering interior space

Objective(s):

Prevent power tool injuries

Prevent buildup of toxic or flammable contaminants



Bad Practice

Worker is using a circular saw with no eye or ear protection, and is not properly supporting the material to be cut.



Best Practice

Worker is cutting off of a stable surface, with appropriate eye and ear protection.

2.0100.1f - Power tool safety



Inspect power and extension cords closely for damage. Follow manufacturer's instructions for repair or replacement.



Generator has been moved off the trailer to ensure no buildup of harmful exhaust gases.



Make sure tools are GFCI-protected or double insulated

2.0100.1h

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



Unsafe

Workers will take precautions to protect themselves on the job site



Best Practice

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

Visit <https://www.osha.gov/SLTC/ergonomics/controlhazards.html> for additional guidance.

2.0100.1i

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

Hand tools will be used for intended purpose

Objective(s):

Prevent injuries



Using tools for other than their intended purpose is dangerous



Use tools in a manner consistent with their intended purpose

Using hand tools only in a manner consistent with their intended purpose. Doing otherwise can cause serious injuries, damage to the tools, damage to materials and equipment. Besides being unsafe, the practice represents poor workmanship and leads to low quality results.

2.0100.1k

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

Ensure staff is aware of risks during summer months, including the symptoms of heat stroke and heat exhaustion

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

2.0100.11

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

Ignition sources will be identified and eliminated (e.g., turn off pilot lights, space heaters, and fuel supply)

Use of flammable material will be reduced and fire-rated materials will be used

Objective(s):

Prevent a fire hazard



Unsafe

Fire hazards like this should be removed from the work area with the permission and/or assistance of the homeowner.



After

After potentially dangerous items have been removed, set combustion appliances to off or pilot to minimize risk of fire.

2.0100.1I - Fire safety



Remove items in close proximity to flue pipes with homeowner permission and/or assistance.



Turn wall mounted heaters off.



Sometimes it may even be necessary to turn the fuel supply off to service an appliance.



When sealing around heat sources like flue pipes, code approved fire rated materials should always be used.

2.0102.1b

Desired Outcome:

Work is completed safely without injury or hazardous exposure

Specification(s):

When working around suspected asbestos-containing material (ACM), the following will not be done:

- Dust, sweep, or vacuum debris
- Saw, sand, scrape, or drill holes in the material
- Use abrasive pads or brushes to strip materials

Attic insulation that looks like vermiculite (as opposed to fiberglass, cellulose, or urethane foams) will not be removed or disturbed

Agencies will refer to the Health and Safety Plan when working around suspected Asbestos Containing Material (ACM)

Objective(s):

Protect workers from toxic exposure



Material identified as vermiculite may contain asbestos

2.0102.1b - Vermiculite



Do not disturb vermiculite by vacuuming, dusting, or sweeping



Do not disturb vermiculite by drilling, sanding, scraping, sawing, etc.

2.0102.1c

Desired Outcome:

Work is completed safely without injury or hazardous exposure

Specification(s):

All materials will be handled in accordance with manufacturer specifications or Safety Data Sheet (SDS) standards to eliminate hazards associated with incorrect, defective, or improperly used respirator and personal protective equipment (PPE)

Objective(s):

Protect workers from toxic exposure



Best Practice

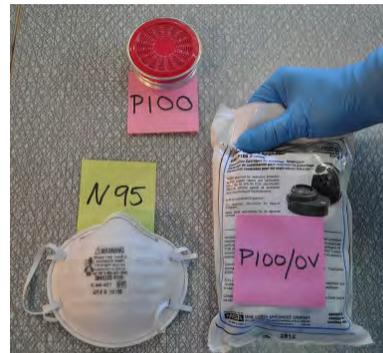
Ensure workers wear appropriate masks or respirators for the material with which they are working

The new Global Harmonization System now calls MSDS simply SDS. The two terms may be used interchangeably for a period, but SDS is now the proper term.

2.0102.1c - Respiratory protection



Check SDS for materials to be used during retrofit to determine what PPE is necessary



Wear respirator or mask appropriate to the materials being used

2.0102.1d

Desired Outcome:

Work is completed safely without injury or hazardous exposure

Specification(s):

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

The Environmental Protection Agency (EPA) 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 workers and occupants from potential lead hazards



In homes built before 1978, test paint before beginning renovation

Tools:

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

EPA RRP certification required to conduct Lead Paint assessment.

2.0102.1d - 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

2.0103.2b

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

Identify and dispose of any mercury-containing thermostats in accordance with Environmental Protection Agency (EPA) guidance

Objective(s):

Protect worker and occupant 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.

2.0103.2e

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

Worker will check for presence of combustible gas leaks before work begins

Leaks will be repaired before work is performed

Objective(s):

Protect worker and occupant from exposure to hazards



Unsafe

Fuel leaks need to be repaired



Safe

Repairs need to be tested and verified to no longer leak

Tools:

1. Combustion gas detector
2. Spray bottle

Materials:

1. Noncorrosive leak detection fluid

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.

2.0103.2e - Combustible gas detection

Measures

Measure 12 Repair - Gas Leak in Crawlspace (flagged)

Comment

#	Material / Labor	Description /Comment	Units
1	Unspecified	Misc Material	Each

Fuel leaks discovered during initial audit should be flagged



Use approved combustion gas sniffer to see if repaired line still leaks



Repeatedly test repair site for leakage over a 10min period



Allow testing solution to sit on newly repaired pipe joint for 10min



Confirm repair and remove flag

2.0103.2f

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):

Workers will check for presence of ambient CO before and during work

CO issues will be addressed before work is performed or continued

Objective(s):

Protect worker and occupant from exposure to hazards



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



If excessive level of CO are found, remediate problems before work continues

Tools:

1. CO meter

2.0103.2f - Carbon monoxide (CO)



1 Test for CO in entire home, particularly around combustion appliances



2 If CO issues are found, clean and tune appliances to remediate issues



3 All workers should wear personal ambient CO monitors and halt work if levels exceed 35ppm

2.0107.5a

Desired Outcome:

Manufactured home is properly installed

Specification(s):

Weatherization work will be deferred until repairs are made if deficiencies that affect worker safety or the integrity of installed measures exist

Objective(s):

Ensure site is safe and ready for upgrade



Photo Credit: Cal Steiner

Safe

Inspect homes for deficiencies before work begins.

Tools:

1. Cordless driver drill
2. Flashlight

Inspect homes for safety before work.

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

Objective(s):

Ensure system does not have fatal problems



 Before

Unsafe combustion appliances indicate need for repair or replacement



 After

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

2.0201.1a - Assessment



Assess existing combustion appliances for damage and replace when necessary



When a simple filter cleaning or replacement will help, make it happen



Ensure there is adequate make-up air -- combustion air inlet in closet



Stop the misuse of combustion appliances -- camp heater in bedroom



Keep occupant apprised of any health or safety concerns

2.0201.1b

Desired Outcome:

Accurate information about appliance safe operation is gathered

Specification(s):

Inspect and test for gas or oil leakage at connections of natural gas, propane piping, or oil systems

If leaks are found, immediate action will be taken to notify occupant to help ensure leaks are repaired

The report will specify repair for leaks and replacement for hazardous or damaged gas or oil connectors and pipes

Objective(s):

Detect fuel gas leaks

Determine and report need for repair



 Before

Fuel lines should be inspected for leakage



 After

If leaks are found, notify occupant immediately to facilitate repair

Tools:

1. Gas sniffer
2. Spray bottle

Materials:

1. Noncorrosive leak detection fluid

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 *piping system* will be repaired or replaced and retested.

2.0201.1b - Fuel leak detection



Inspect exterior gas and oil lines for leaks and damage



Inspect flex lines for damage, and check date on ring for pre-1973 hardware

2.0201.1c

Desired Outcome:

Accurate information about appliance safe operation is gathered

Specification(s):

The presence and operability of a draft regulator will be verified and tested

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

Objective(s):

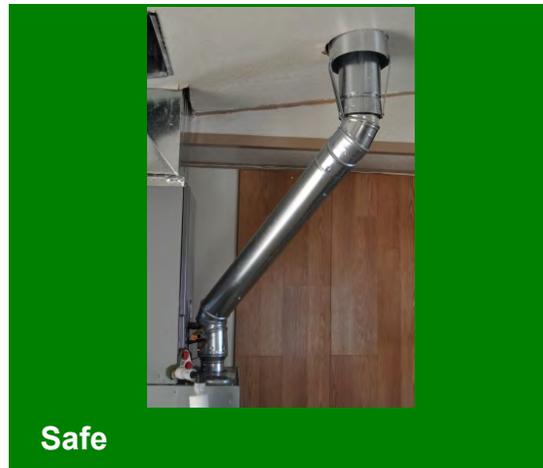
Determine if a regulator is present and working

Determine whether vent system is in good condition and installed properly



Unsafe

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



Safe

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

2.0201.1d

Desired Outcome:

Accurate information about appliance safe operation is gathered

Specification(s):

Baseline pressure will be measured in Combustion Appliance Zone (CAZ) with reference to outdoors

Objective(s):

Measure pressure difference between combustion zone and the outside under natural conditions



Natural conditions: wintertime set-up, air handler and exhaust fans off, all interior doors open

Tools:

1. Manometer

2.0201.1e

Desired Outcome:

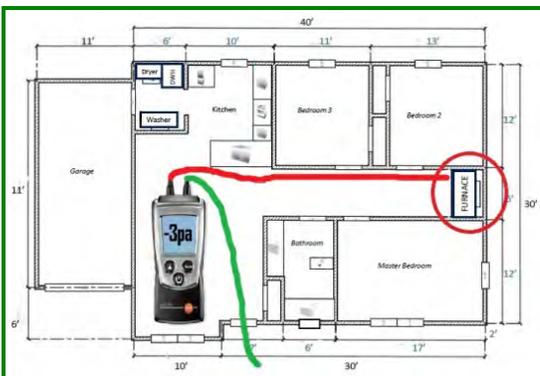
Accurate information about appliance safe operation is gathered

Specification(s):

CAZ depressurization testing will be administered on all natural draft equipment

Objective(s):

Measure combined effect of mechanical system fans on combustion zone



Best Practice

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

2.0201.2a

Desired Outcome:

Buildup of dangerous combustion byproducts in the living space prevented

Specification(s):

When combustion air is needed air will be provided from the exterior of the structure

Objective(s):

Prevent combustion byproducts from entering the house

For homes with one permanent opening: 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: 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: a minimum free area of 1 in² per 2,000 Btu/h (1,100 mm²/kW) of total input rating of all appliances

2.0201.2b

Desired Outcome:

Buildup of dangerous combustion byproducts in the living space prevented

Specification(s):

If replacing appliances, a sealed-combustion, direct-vent appliance will be installed in accordance with manufacturer specifications, and in accordance with industry acceptable standards

Replacement equipment venting will be assessed to ensure other existing equipment is not adversely affected

Objective(s):

Prevent combustion byproducts from entering the house



 Before

Damaged combustion appliances beyond repair should be replaced



 After

Sealed-combustion, direct-vent appliances should replace unsafe appliances

Tools:

1. Digital manometer and air line tubing
2. Personal carbon monoxide detector
3. Combustion analyzer
4. Combustible gas leak detector

Always perform combustion safety testing on newly installed equipment to ensure it is performing properly.

2.0201.2b - New appliances



Two-pipe 90% efficiency furnaces are viable replacement appliances



Direct vent combustion appliances are also viable replacements

2.0201.2c

Desired Outcome:

Buildup of dangerous combustion byproducts in the living space prevented

Specification(s):

CO detection or warning equipment will be installed outside of each separate sleeping area in the immediate vicinity of the bedrooms in accordance with ASHRAE 62.2 and authority having local jurisdiction

Installation will be accomplished by a licensed electrician when required by local code

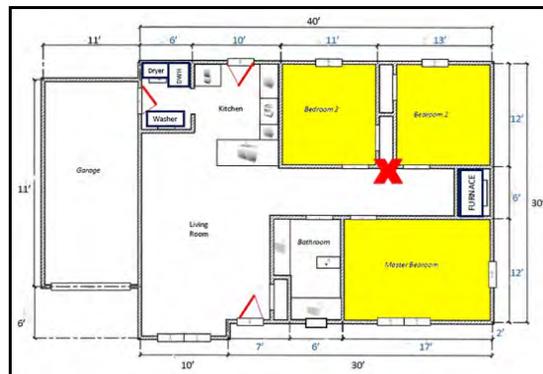
Objective(s):

Alert occupant to CO exposure



Best Practice

Carbon Monoxide alarms should be installed according to local codes



Best Practice

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

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



Best Practice

Test gas oven for carbon monoxide using a combustion gas analyzer

Tools:

1. Combustion analyzer with probe

2.0201.2f

Desired Outcome:

Buildup of dangerous combustion byproducts in the living space prevented

Specification(s):

Replacement of solid fuel-burning appliance with UL-listed and EPA- certified appliances if the existing appliance is not UL-listed or has signs of structural failure

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

Since 1988, the EPA has regulated particulate emissions from wood heaters. The limit is 7.5 grams per hour for non-catalytic appliances, and 4.1 grams per hour for catalytic appliances.

Follow all manufacturer's installation specifications, especially regarding venting, mounting surfaces, and distance to surrounding surfaces.

2.0201.2f - Solid fuel-burning appliances



Locate data plate to find out appliance ratings



Check appliance rating plates for EPA and UL markings
(or CSA, ETL, or WH markings)

2.0201.3a

Desired Outcome:

Accurate information about appliance safe operation is gathered

Specification(s):

Appliance spillage testing will be administered on natural draft appliances and shall not exceed 2 minutes

Objective(s):

Detect excessive spillage of combustion gases



Test natural draft furnace or water heater for spillage in excess of 2min



Test all sides of natural draft flues since draft may not be uniform

Tools:

1. Smoke pencil
2. Timer
3. Mirror

2.0201.3b

Desired Outcome:

Accurate information about appliance safe operation is gathered

Specification(s):

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

For CO levels exceeding 100 ppm as measured or 200 ppm air-free measurement, 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 and power-vented appliances (without atmospheric chimneys)

Objective(s):

Measure CO and report excessive levels



Unsafe

CO levels cannot exceed 100ppm as measured, unless to manufacturer specs



Best Practice

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

Tools:

1. Combustion analyzer with probe
2. Drill

2.0201.3b - Carbon monoxide (CO) test in appliance vent



CO levels cannot exceed 100ppm, or 200ppm air-free CO



Test undiluted flue gases in induced-draft furnaces



Test undiluted flue gases in natural draft water heaters



Test accessible exhaust outlets for power-vented appliances



Test accessible exhaust outlets for direct-vent appliances

2.0201.3c

Desired Outcome:

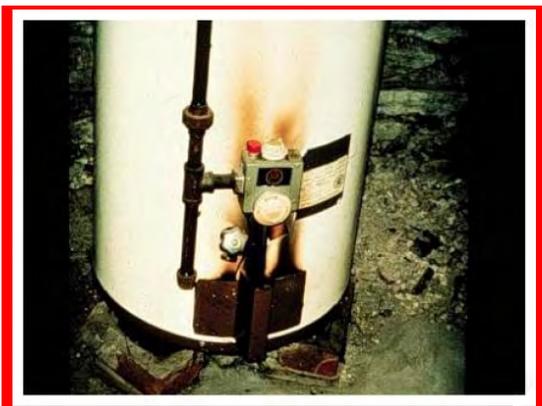
Accurate information about appliance safe operation is gathered

Specification(s):

Final combustion testing will be conducted at project completion to ensure compliance with the above specifications

Objective(s):

Ensure safe operation of combustion appliance within the whole house system after any repair project



 Before

Damaged and unsafe combustion appliances should be replaced



 After

Before leaving retrofit, test new combustion appliances to verify they are working safely

2.0201.3c - Final test out



Complete spillage test using chemical smoke pencil



Complete carbon monoxide testing using a CO detector



Complete draft test using a manometer

2.0202.1b - Occupant education



Unvented space heaters significantly increase the risk of house fires



Unvented combustion gases cause a hazard to all occupants



Unvented space heaters can create moisture issues in homes, leading to black mold

2.0204.1d

Desired Outcome:

Isolate combustion water heater closet from conditioned space

Specification(s):

Blower door assisted zonal pressure diagnostics will be used to verify isolation has been achieved

Objective(s):

Prevent combustion gases from entering living area



 Before

The reading is closer to 0, indicating strong connection to the inside.



 After

The reading is closer to 50, indicating strong connection to the outside.

Tools:

1. blower door assembly
2. manometer
3. 1/4" hose
4. steel tube or probe
5. drill

2.0204.1d - Post-work testing/verification



Depressurize the house to 50 pascals.



Close the CAZ door or otherwise gain access to the CAZ.



Reading is closer to 50 pascals indicating combustion closet is connected to the outside.

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 and per manufacturer's specifications

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 the ASHRAE 62.2 and manufacturer specifications as required by the authority having jurisdiction

Objective(s):

Ensure proper installation



Houses should have carbon monoxide monitors installed near sleeping areas



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

An approved CO alarm will be installed outside of each separate sleeping area in the immediate vicinity of the bedrooms in all dwelling units. 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 62.2.2016 and NFPA 720 is required.

2.0403.4a

Desired Outcome:

Durable, effective ground moisture barrier that provides ongoing access and minimizes ground vapor

Specification(s):

If existing conditions of the ground and skirting mandates, a moisture barrier that covers the crawl space ground will be installed with allowances for structural supports (piers) and accessibility

Objective(s):

Reduce ground moisture entering crawl space



Manufactured home crawlspace with incomplete ground vapor barrier



Manufactured home crawlspace with complete ground vapor barrier

Tools:

1. Utility knife
2. Hammer or mallet
3. Scissors

Materials:

1. Polyethylene vapor barrier, 6-mil thickness or greater
2. Waterproof tape
3. Polyurethane caulking or construction adhesive
4. Landscape staples

Aim for complete coverage. If access to the entire crawlspace is impossible, cover all accessible areas. Overlap seams in vapor barrier by at least twelve inches, and seal them with waterproof tape and/or polyurethane caulk or adhesive. Wrap and cover support piers at least twelve inches high.

2.0403.4a - Coverage



1 Remove skirting as needed for access to crawlspace



2 Measure, cut, and spread vapor barrier material after removing debris over 1/2" in size. Notch around obstructions



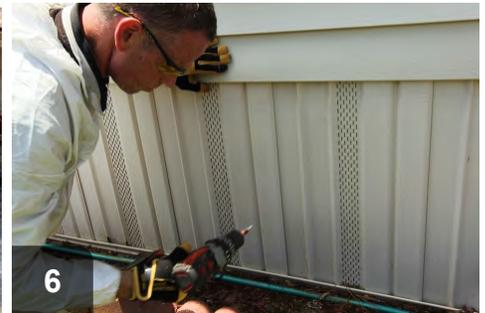
3 Wrap piers and columns at least six inches high. Use additional material to cover any gaps and holes in vapor barrier



4 Secure vapor barrier to ground with corrosion-resistant landscape staples, or weigh it down with ballast



5 Remove tools and excess material



6 Reinstall skirting

2.0403.4b

Desired Outcome:

Durable, effective ground moisture barrier that provides ongoing access and minimizes ground vapor

Specification(s):

A ground moisture barrier with a rating of no more 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

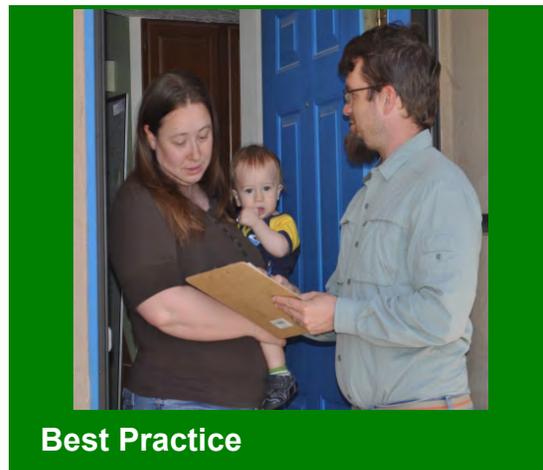
Objective(s):

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



Best Practice

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



Best Practice

Talk to occupant about expected life of ground barrier and eventual need to replace it

Materials:

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

The higher a material's perm rating, the more vapor can pass through said material. Drywall typically has a perm rating of approximately 50.

2.0403.4c

Desired Outcome:

Durable, effective ground moisture barrier that provides ongoing access and minimizes ground vapor

Specification(s):

When seams exist, they will be overlapped a minimum of 12" using reverse or upslope lapping technique

Objective(s):

Keep water under the liner

Reduce likelihood of damage at seams



In Progress

Layer moisture barrier in a reverse shingle pattern so that uphill sheeting lays under downhill



Best Practice

Once layered, secure seams with landscape staples or tape

Tools:

1. Stapler
2. Utility knife
3. Drill

Materials:

1. Landscaping staples
2. Plastic sheeting (at least 4mil)
3. Ballast
4. Furring strips
5. Moisture-resistant adhesive tape

Two different colors of poly used to highlight different layers

2.0403.4c - Overlap seams



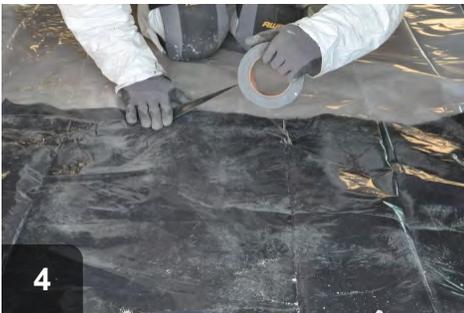
1 Determine which direction ground slopes and, if not working from uphill down, fold back barrier at lower areas



2 Measure uphill barrier at least 12 inches and mark where downhill barrier should reach



3 Layer downhill barrier over uphill to marked position, overlapping 12 inches, in reverse shingle pattern



4 Fasten seam with tape or landscape staples to prevent barrier from moving and allowing moisture infiltration

2.0403.4d

Desired Outcome:

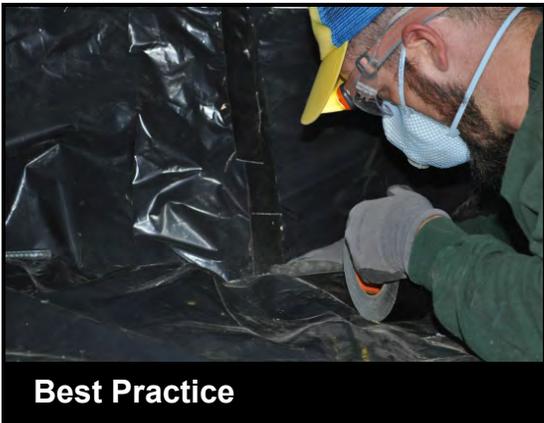
Durable, effective ground moisture barrier that provides ongoing access and minimizes ground vapor

Specification(s):

Ground moisture barrier may be fastened to ground with durable fasteners

Objective(s):

Prevent movement of the ground moisture barrier



Taping seams with waterproof adhesive tape can prevent barrier from moving



Fasten moisture barrier in place using ballast or corrosion-resistant fasteners, such as landscaping staples

Tools:

1. Hammer

Materials:

1. Landscaping staples
2. Ballast
3. Water-resistant adhesive tape

2.0602.1a

Desired Outcome:

Prevention of static electric shock to the insulation installer when using rigid tubing

Specification(s):

Rigid fill tubes will be made of a material that will not hold an electric charge, such as Schedule 40 PVC Electrical Conduit, or be grounded

Objective(s):

Prevent injury to the installer



Best Practice

Rigid fill tubes should be low-conductivity and be grounded

Tools:

1. Wrench

Materials:

1. Couplers
2. Schedule 40 PVC fill tube
3. Grounding wire
4. Grounding rod

2.0602.1a - Rigid fill tube



Select rigid fill tubes that are low conductivity -- Schedule 40 PVC fill tube



Attach grounding wire to fill tubes to minimize shock risk



Attach grounding wire to rod with coupler



Blow insulation

2.0602.1b

Desired Outcome:

Prevention of static electric shock to the insulation installer when using rigid tubing

Specification(s):

For an additional level of protection, the metal coupler on the hose will be connected to the grounding wire

Grounding wire will be connected to the grounding rod

Grounding rod will be driven into the ground a minimum of 8' when possible; grounding wire will be connected in compliance with local code and authority having jurisdiction

Objective(s):

Divert static discharge of electricity to ground instead of installer



Unsafe

Ungrounded fill tubes can build up static electricity during insulation blowing



Best Practice

Fill tubes should be grounded to prevent electric shock to workers

Tools:

1. Sledgehammer
2. Wrench

Materials:

1. Grounding rod, at least 8'
2. Grounding wire
3. Metal coupler
4. Grounding coupler

2.0602.2a

Desired Outcome:

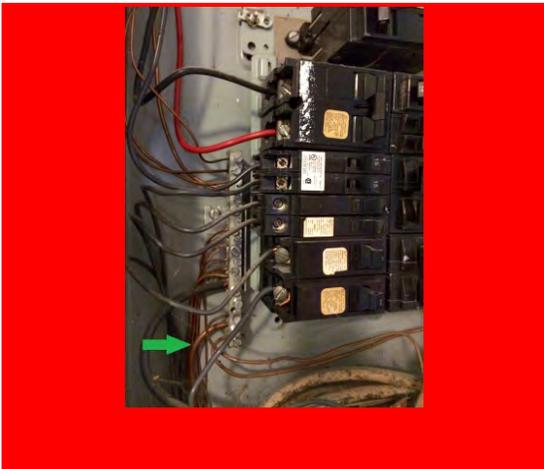
Prevention of injury to the installer and occupant, and prevent damage to the structure, if required by authority having jurisdiction

Specification(s):

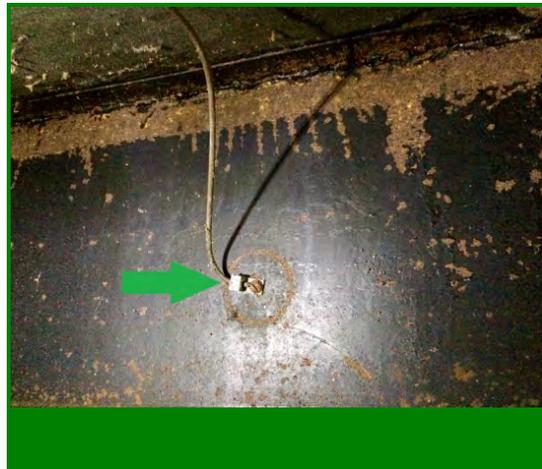
Metal skin and frame will be grounded through the panel box to avoid electrical shock

Objective(s):

Prevent injury to the installer



Locate 6- or 8-gauge solid copper ground wire in panel box



Verify that the ground wire is attached to the chassis (and metal siding if so equipped)

Tools:

1. Flashlight
2. Screwdriver (to remove panel box cover)

The frame and metal siding ground wire attachment points can be found under the home below the electric service entrance and panel box.

2.0602.2b

Desired Outcome:

Prevention of injury to the installer and occupant, and prevent damage to the structure, if required by authority having jurisdiction

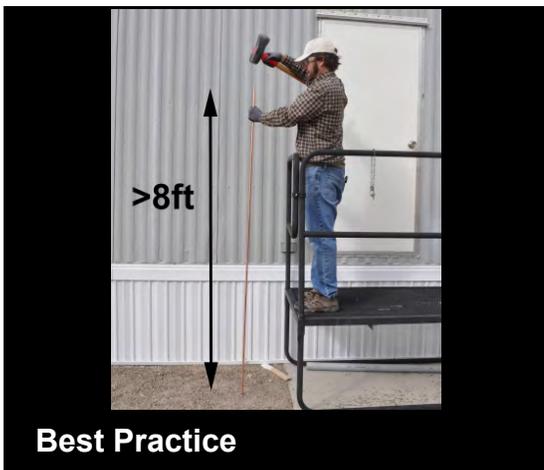
Specification(s):

For an additional level of protection, metal fill tube will be connected to the grounding wire

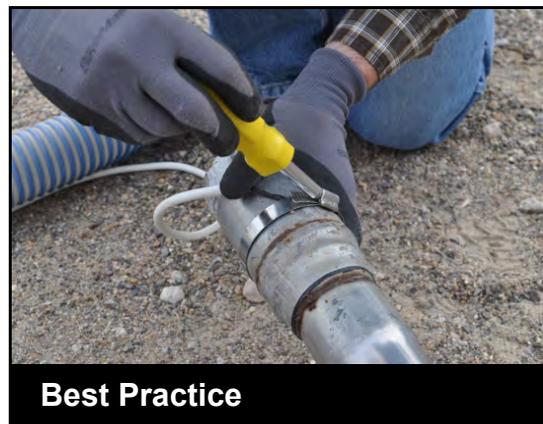
Grounding wire will be connected to the copper grounding rod that is driven into the ground a minimum of 8' when possible and required by code or authority having jurisdiction

Objective(s):

Divert house electric current to ground instead of installer in the event of contact with a live wire



To prevent static electric shock, a grounding rod should be utilized



Attach grounding wire to metal of fill tube, not to flexible tubing

Tools:

1. Sledgehammer
2. Wrench

Materials:

1. Grounding rod, at least 8'
2. Grounding wire
3. Metal coupler
4. Metal fill tube

2.0602.2c

Desired Outcome:

Prevention of injury to the installer and occupant, and prevent damage to the structure, if required by authority having jurisdiction

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 electric cords will not be used

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

Metal ladders will be avoided

Aluminum foil products will be kept away from live wires

For arc flash hazards, NFPA 70E will be consulted

Objective(s):

Avoid electrical shock and arc flash hazards



Unsafe

Inspect house for unsafe electrical situations



Best Practice

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

2.0602.2c - Electrical tool safety



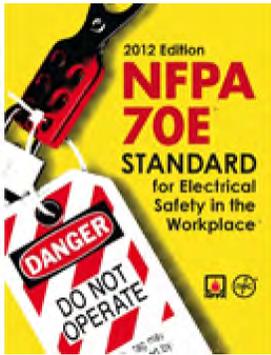
Use GFCIs and three-wire extension cords for all power tools



Electrical wiring should not be located near a water source



Use fiberglass ladders in place of metal



Follow NFPA 70E 2012 guidelines for arc flash hazards

2.0602.2d

Desired Outcome:

Prevention of injury to the installer and occupant, and prevent damage to the structure, if required by authority having jurisdiction

Specification(s):

If aluminum wiring is present, work on the home will be stopped until the suspect wiring is inspected and determined to be safe by a licensed electrician

After energy retrofit is completed, wiring will be reinspected by a licensed electrician

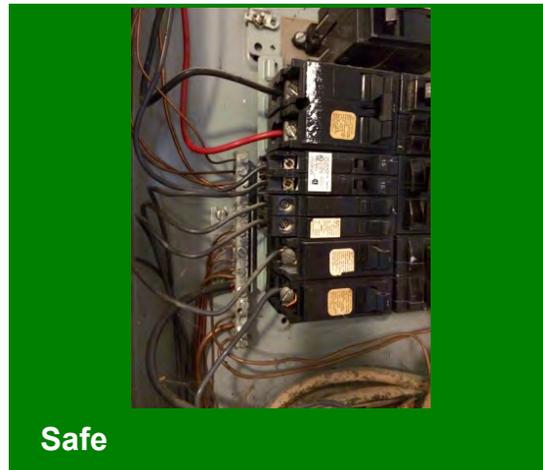
Objective(s):

Prevent injury to installer and occupant

Prevent damage to structure



Have a certified electrician perform a load test before any weatherization work if aluminum wire is present.



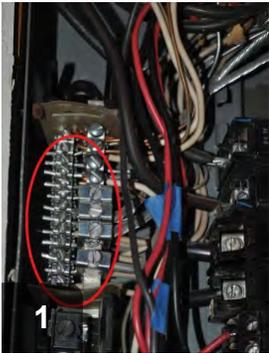
This panel does not contain aluminum wire.

Tools:

1. Screwdriver (to remove panel cover)
2. Flashlight

Check for the presence of aluminum wire (identified by its light gray color). If aluminum wire is present, do not work on the home until a certified electrician has performed a thorough inspection and determined that the wiring is safe.

2.0602.2d - Aluminum wiring



Inspect panel box for presence of (silver or gray colored) aluminum wire



Have a certified electrician inspect every aluminum wire connection in the home



After electrician verifies wiring is safe, proceed with retrofit work



Perform retrofit measures



When retrofit is complete, have certified electrician re-check wiring for safety

3.1001.4b

Desired Outcome:

Penetrations sealed to prevent air leakage and moisture movement between unconditioned and conditioned space

Specification(s):

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

The infill or backing will not bend, sag, or move once installed

All accessible damaged vapor barrier will be repaired

Penetration through the air barrier will be repaired

Objective(s):

Ensure closure is permanent and supports any load (e.g., wind, insulation, mechanical pressures)

Ensure sealant is effective and durable



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



Gaps should be sealed to maintain air barrier

Tools:

1. Headlamp
2. Caulk gun

Materials:

1. Backer rod
2. Sealant
3. Adhesive tape
4. Plastic sheeting (at least 6 mil)

3.1001.4b - Air sealing penetrations



Prepare work space by removing any insulation



Infill with backer rod



Apply appropriate caulking to ensure backing/infill does not move



Visually inspect to verify no gaps remain



Patch holes in air and/or vapor barriers as well



Repair vapor barrier



Complete seal

3.1001.4c

Desired Outcome:

Penetrations sealed to prevent air leakage and moisture movement between unconditioned and conditioned space

Specification(s):

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

Sealants will be compatible with all adjoining surfaces

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

Objective(s):

Create a permanent seal

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

Create a continuous seal



Bad Practice

Avoid sealants that do not allow for expansion between dissimilar materials



Best Practice

Flexible sealants compensate for differential expansion and maintain a seal

Tools:

1. Caulk gun
2. Spray foam gun

Materials:

1. Caulk
2. Spray foam

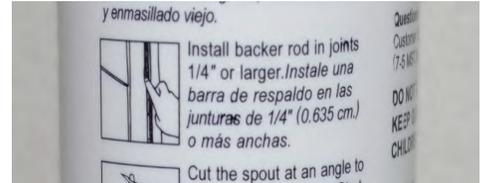
3.1001.4c - Sealant selection



Caulking can be used to span gaps up to 1/4 inch



Spray foam can be used to span gaps up to 3 inches



Check manufacturer specifications to verify spanning capabilities



Also check manufacturer specs for incompatibility with intended surfaces

3.1001.4d

Desired Outcome:

Penetrations sealed to prevent air leakage and moisture movement between unconditioned and conditioned space

Specification(s):

Ceiling repair material must meet or exceed strength of existing ceiling material

Ceiling repair must span from truss to truss or add blocking as needed for support

The backing or infill will not bend, sag, or move once installed

All accessible damaged vapor barriers will be repaired

Penetrations through the air barrier must be repaired

Objective(s):

Ensure ceiling is structurally sound

Minimize air leakage

Ensure closure is permanent and supports expected wind and mechanical pressure loads

Ensure sealant does not fall out



 Before

Hole in drywall ceiling



In Progress

Drywall patch in place

Tools:

1. 6-inch and 12-inch drywall taping knives
2. Sanding block or sanding sponge
3. Utility knife
4. Keyhole saw
5. Screw gun

Materials:

1. Drywall or paneling
2. Fiberglass joint tape
3. Joint compound
4. Drywall screws
5. Support material if needed (typically 1X4, 1X6, or 2X4 dimensional lumber)

For holes in paneled ceilings, use matching panels for repairs. Consider replacing entire sections to avoid creating unsightly mismatched patches. For small holes, enlarge to a rectangular shape and install 1 X 4 blocks above two edges of the hole. For larger holes, enlarge opening to centers of nearest trusses and fasten the patch to the framing.

3.1001.4e

Desired Outcome:

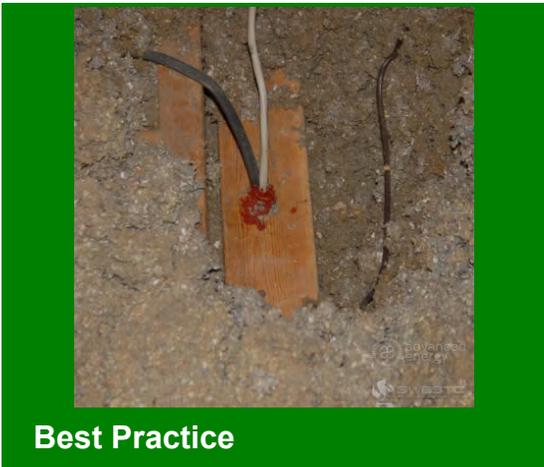
Penetrations sealed to prevent air leakage and moisture movement between unconditioned and conditioned space

Specification(s):

Materials will be used or installed in accordance with product manufacturer specifications

Objective(s):

Select materials to ensure durable and permanent repair



Choose durable, high quality sealants that are compatible with existing materials

Tools:

1. Caulking gun
2. Reusable spray foam gun
3. Utility knife

Materials:

1. Caulk
2. Foam sealant
3. Foam board
4. Drywall
5. Joint compound

3.1001.4f

Desired Outcome:

Penetrations sealed to prevent air leakage and moisture movement between unconditioned and conditioned space

Specification(s):

Only noncombustible materials will be used in contact with chimneys, vents, and flues

Local codes will be referenced

Objective(s):

Prevent a fire hazard



 Before

Gaps around combustion exhaust flues need to be sealed



 After

Sealed penetrations and chases should utilize high-temperature materials

Tools:

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

Materials:

1. Fire caulk
2. Non-combustible material such as aluminum or galvanized steel flashing or cement board
3. Appropriate fasteners

3.1001.4f - High temperature application



1 Prepare work area by removing any insulation and debris



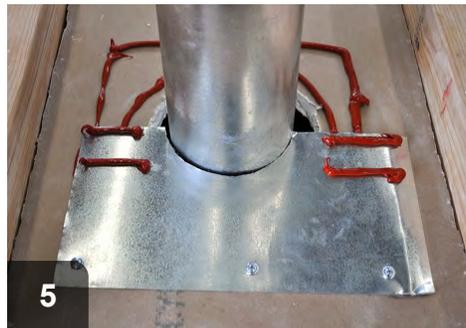
2 Use high-temperature caulking (600F min)



3 Apply first ring of caulking to match shape of opening



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



5 Fasten rigid material and apply additional caulking



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

3.1101.1b

Desired Outcome:

Penetrations sealed to minimize air leakage and moisture movement between unconditioned and conditioned space; all repairs will maintain structural integrity

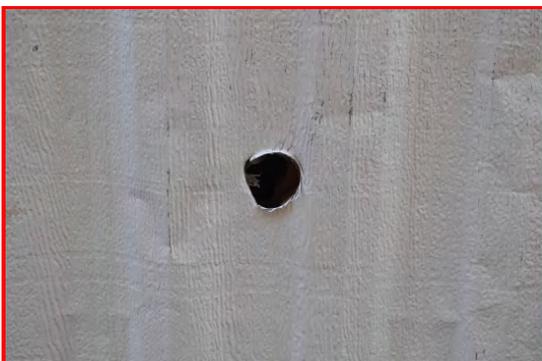
Specification(s):

Like material and/or compatible materials will be used for repairs

Materials will be selected to comply with manufactured housing rules and regulations (e.g., Manufactured Housing Institute)

Objective(s):

Select materials to ensure durable and permanent repair



 Before

Hole in exterior wall of manufactured home aluminum siding



 After

Completed wall patch

Tools:

1. Sheet metal nibbler
2. Power saw
3. Snips
4. Screw gun
5. Caulking gun

Materials:

1. Aluminum siding or flashing
2. Oriented Strand Board (OSB) sheathing
3. Vinyl siding
4. Galvanized steel
5. Corrosion-resistant fasteners
6. High quality caulk formulated for exterior use

3.1101.2b

Desired Outcome:

Penetrations sealed to minimize air leakage and moisture movement between unconditioned and conditioned space; all repairs will maintain structural integrity

Specification(s):

All accessible holes and penetrations in top and bottom plates will be sealed

Backing or infill will be provided as needed to meet the specific characteristics of the selected sealant and the characteristics of the penetration

Objective(s):

Minimize air leakage

Maintain durability

Ensure resulting closure is permanent and supports expected wind and mechanical pressure loads

Ensure sealant is effective and durable



Unsealed penetrations through top plate



Sealed wiring penetrations through top plate

Tools:

1. Caulking gun
2. Reusable spray foam gun

Materials:

1. Caulk
2. Spray polyurethane foam
3. Foam backer rod or pieces of fiberglass batt

3.1101.2b - Interior wall air sealing



1
Locate and expose penetrations to prepare for sealant



2
Use caulk or foam (approved by local code) to seal wiring penetrations through top plate



3
Ensure that all accessible gaps, holes, and penetrations are filled

3.1101.2c

Desired Outcome:

Penetrations sealed to minimize air leakage and moisture movement between unconditioned and conditioned space; all repairs will maintain structural integrity

Specification(s):

Like material and/or compatible materials will be used for repairs

Materials will be selected to comply with manufactured housing rules and regulations (e.g., Manufactured Housing Institute)

Objective(s):

Select materials to ensure durable and permanent repair



Before

Identify wall material and patch holes with like material, such as drywall or panelling



In Progress

Patch has been cut from drywall the same thickness as existing wall material

Tools:

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

Materials:

1. Drywall
2. Panelling
3. Fasteners
4. Wood for support
5. Spackle

3.1101.3b

Desired Outcome:

Penetrations sealed to minimize air leakage and moisture movement between unconditioned and conditioned space; all repairs to maintain structural integrity

Specification(s):

All accessible holes and penetrations in top and bottom plates will be sealed

Backing or infill will be provided as needed to meet the specific characteristics of the selected sealant and the characteristics of the penetration

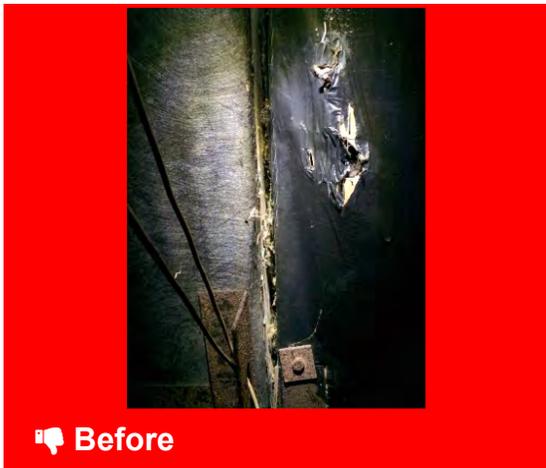
Objective(s):

Minimize air leakage

Maintain durability

Ensure resulting closure is permanent and supports expected wind and mechanical pressure loads

Ensure sealant is effective and durable



Cobwebs may indicate air leaks at the marriage line



Completed air sealing at marriage line

Tools:

1. Caulking gun
2. Reusable spray foam gun

Materials:

1. Extruded polystyrene ((XPS) foam board
2. Caulk
3. Spray foam
4. Foam backer rod or fiberglass batt insulation

3.1101.3b - Marriage wall air sealing of holes and penetrations



1 Clean belly wrap before air sealing



2 Stuff wide gaps in the marriage line with fiberglass insulation or foam backer rod before applying sealant



3 Apply foam or caulking over backer

3.1101.3c

Desired Outcome:

Penetrations sealed to minimize air leakage and moisture movement between unconditioned and conditioned space; all repairs to maintain structural integrity

Specification(s):

All accessible holes and penetrations at marriage lines will be sealed continuously at end walls, floors, and ceiling

Backing or infill will be provided at the marriage line as needed

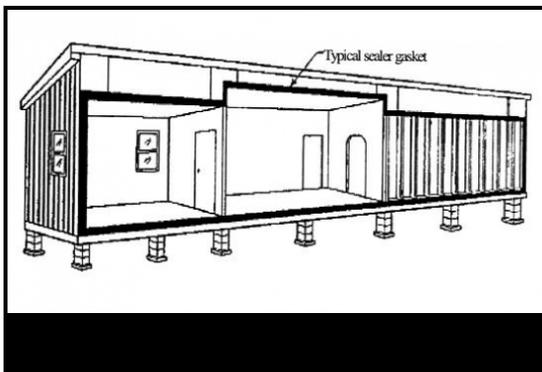
All remaining gaps will be sealed with an approved material

Objective(s):

Minimize air leakage

Maintain durability

Ensure sealant is effective and durable



Identify leaks in marriage line using a blower door

Tools:

1. Reusable spray foam gun
2. Caulking gun
3. Utility knife
4. Tape measure
5. Square
6. Screw gun
7. Hammer
8. Prybar
9. Blower door
10. Chemical smoke dispenser

Materials:

1. Caulk
2. Spray foam
3. Foam board
4. Screws

You may need to remove trim to determine what type of sealing is needed at the marriage line. Some original installations use a compressed open-cell polyurethane foam sealing strip with excellent air sealing properties and will need little or no additional work. Other installations may feature fiberglass or other ineffective air sealing measures and require extensive caulking and foaming to reduce air infiltration. Use a blower door to **pressurize** the house and use smoke to pinpoint leak locations.

3.1101.3c - Marriage line air sealing



Identify leaks in marriage line using a blower door and smoke



Foam, caulk, and seal leaks between halves of double wide manufactured homes

3.1201.5c

Desired Outcome:

Windows and doors are operable, sealed, and weathertight

Specification(s):

All egress windows will be operable as required by local codes

All egress doors will be operable as required by local codes

Objective(s):

Maintain operability of egress windows and doors



Safe

Windows and doors should be free and clear of obstructions and operate smoothly with no special knowledge.

3.1201.5c - Operable windows and doors



Window sill height should be no more than 44 inches from the floor.



Egress windows should be more than 24" high.



Egress windows should be more than 20" wide.



Doors should open easily from the inside, with no key or special knowledge of the locking system.



Manufactured housing should have two egress doors located away from one another. Stairs or ramps may be needed outside.

3.1201.5d

Desired Outcome:

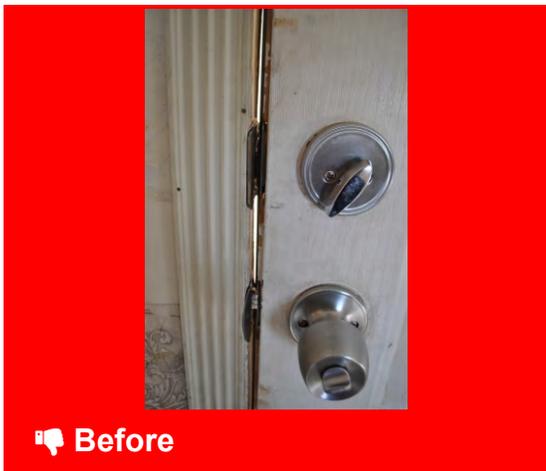
Windows and doors are operable, sealed, and weathertight

Specification(s):

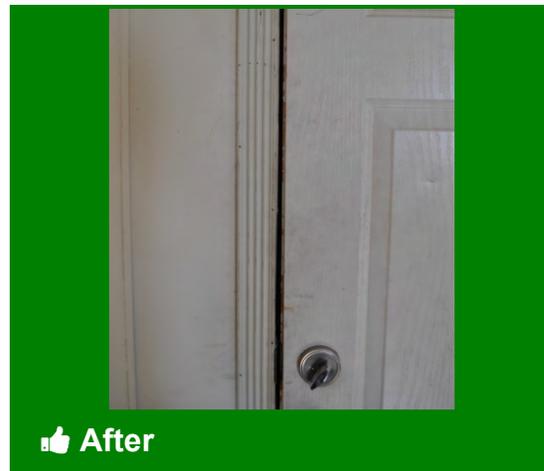
Details that reduce air infiltration will be repaired, replaced, sealed, or installed (e.g., plastic gliders, weatherstripping, cranks, latches, locks, knobs, thresholds)

Objective(s):

Reduce air infiltration



Light visible through door jamb indicates air infiltration



After weatherstripping and adjustment of door in jamb, air infiltration is eliminated

Tools:

1. Drill/screwdriver
2. Utility knife
3. Tape measure
4. Caulk gun
5. Metal snips

Materials:

1. Weatherstripping
2. Door sweep
3. Fasteners
4. Caulk
5. Felt corner pads

3.1201.5d - Air infiltration



1
Door jamb is missing any weatherstripping



2
Measure door jamb for weatherstripping



3
Install new weatherstrip



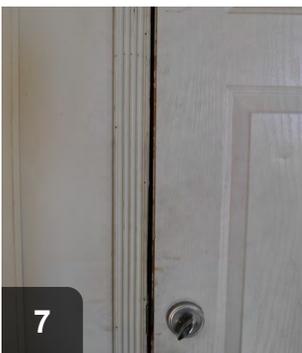
4
Measure bottom of door for door sweep



5
Install new door sweep



6
Adjust strike-plate and door jambs as necessary to secure a good fit



7
If properly adjusted, light should no longer be visible around door and air movement should no longer be detected

3.1201.5e

Desired Outcome:

Windows and doors are operable, sealed, and weathertight

Specification(s):

Details that reduce water infiltration will be repaired, replaced, or installed (e.g., replace missing glazing on sash, exterior caulking, exterior storm windows, storm doors, drip cap, J-channel, flashing)

Objective(s):

Reduce water infiltration



Install and caulk drip caps over manufactured home windows



Install and caulk drip caps over manufactured home doors

Tools:

1. Caulking gun
2. Cordless driver/drill
3. Razor scraper
4. Metal snips

Materials:

1. Caulk formulated for exterior use with 20-year or greater durability
2. Glass
3. Glazing strips
4. J-channel
5. Putty tape
6. Flashing

3.1201.5f

Desired Outcome:

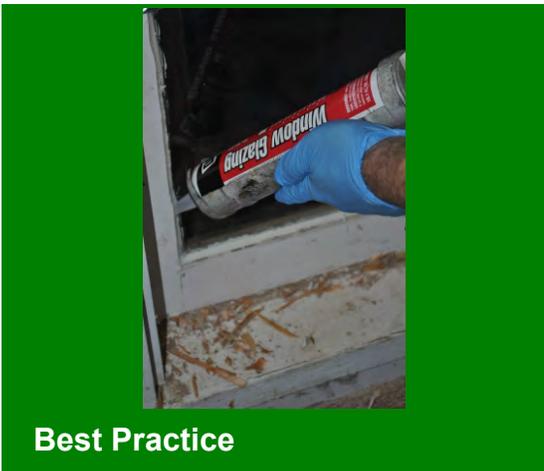
Windows and doors are operable, sealed, and weathertight

Specification(s):

Materials will be used or installed in accordance with product manufacturer specifications

Objective(s):

Select materials to ensure durable and permanent repair



Best Practice

Read manufacturer specifications to ensure proper use of materials

3.1201.6b

Desired Outcome:

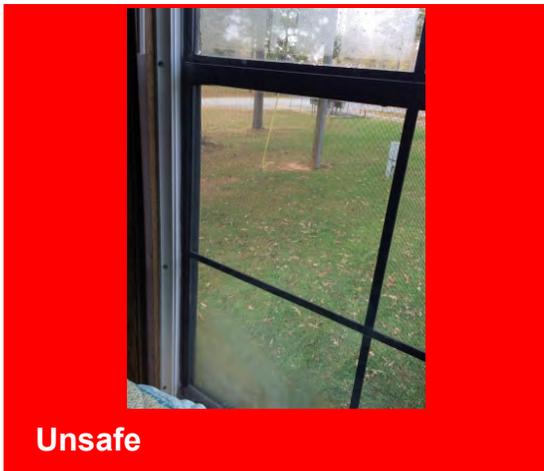
Minimize air infiltration through existing leaky windows while maintaining safe egress for occupants

Specification(s):

Fixed interior storm windows will not be installed in egress locations

Objective(s):

Safety



Do not install fixed storm windows in bedroom windows designated as egress locations



Fixed storm windows may be installed in non-egress locations only

Storm windows installed in egress (bedroom) windows must be operable or removable, and conform to the following standard: Voluntary Standard Egress Window Systems for Utilization in Manufactured Housing, AAMA 1704-85

3.1201.6c

Desired Outcome:

Minimize air infiltration through existing leaky windows while maintaining safe egress for occupants

Specification(s):

Operable interior storm windows will be installed in accordance with manufacturer specifications

Objective(s):

Minimize air leakage

Provide safe egress for occupants



No interior storm window has been installed.



Storm window has been installed according to manufacturers specifications and operates smoothly.

Tools:

1. drill

Materials:

1. mechanical fasteners
2. weatherstripping

3.1201.6c - Installing operable storm window



Ensure the perimeter surfaces are clean and ready to accept sealant.



Install weatherstrip or other appropriate sealant to the perimeter of the opening.



Install the window, ensuring it is level in the opening.



Secure the window to the opening, being sure the mechanical fasteners compress the desired sealant.



Storm window has been installed according to manufacturers specifications and operates smoothly.

3.1201.6d

Desired Outcome:

Minimize air infiltration through existing leaky windows while maintaining safe egress for occupants

Specification(s):

Interior storm windows will be operable and egress rated in egress locations

Objective(s):

Provide safe egress for occupants



Safe

Only operable storm windows conforming to HUD standards may be installed in egress (bedroom) windows

Storm windows installed in egress (bedroom) windows must be operable or removable, and conform to the following standard: Voluntary Standard Egress Window Systems for Utilization in Manufactured Housing, AAMA 1704-85

3.1202.3c

Desired Outcome:

Glass complete and intact

Specification(s):

Damaged glass will be removed

Objective(s):

Safely remove old glass



Before

Broken or cracked window glass should be replaced to minimize air leakage



In Progress

Broken glass needs to be cleared away completely before installing new glass

Tools:

1. Brush
2. Dust pan
3. Vacuum
4. Utility knife
5. Gloves

3.1202.3c - Broken glass removal



1
Remove exterior stops--these will probably not be salvagable



2
Wearing protective gloves, remove large glass pieces carefully



3
Sweep up all remaining small glass slivers



4
Sash should be completely clear of debris before moving forward with installation

3.1202.3d

Desired Outcome:

Glass complete and intact

Specification(s):

Opening will be cleaned

Original sealant/material will be removed

Objective(s):

Prepare opening for new glass



In Progress

Remove all debris, glazing tape, and glass from sash



In Progress

Sash surface must be clean before mounting new glass

Tools:

1. Scraper
2. Lint-free cloth

Materials:

1. Cleaning solution or cleaning wipes

3.1202.3d - Opening preparation



Clean all sealant and glazing off sash to return to smooth surface



Clean sash with cleaning solution and lint-free cloth. Allow to dry before applying sealant

3.1202.3e

Desired Outcome:

Glass complete and intact

Specification(s):

Replacement glass will be sized to original width, height, and depth

Stops will be replaced or installed

Glass will be sealed in accordance with original installation design

Glass will be selected with comparable tint and coating (color and look)

Tempered or safety glass will be used as required by local code

Objective(s):

Install, seal, and secure new glass in place



Sash should be completely clear debris before installing new glass



Replacement glass should match previous tint and dimensions, and be tempered, if location requires it

Tools:

1. Caulk gun
2. Tape measure

Materials:

1. New glass, measured to fit, tempered if necessary
2. Glazing or replacement stops
3. Adhesive sealant
4. Window cleaner

3.1202.3e - New glass installation



1 Measure sash for width of replacement glass -- cut glass to 1/4" less than sash width



2 Measure sash for height of replacement glass -- cut glass to 1/4" less than sash height



3 Apply sealant to sash with bead at least 3/16" wide



4 Run sealant bead around entire sash to seal glass from the interior



5 Install new glass, ensuring 1/8" gap from frame on all sides



6 Apply glazing or install replacement stops to seal window from exterior



7 Clean glass to ensure than no out of place adhesive or glazing remains to bake onto glass

3.1203.3e

Desired Outcome:

Smooth operation and an airtight and weathertight fit of replacement windows and doors

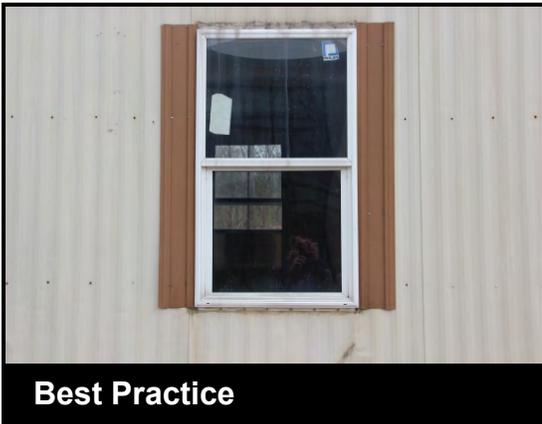
Specification(s):

Window or door units will be installed in accordance with manufacturer specifications

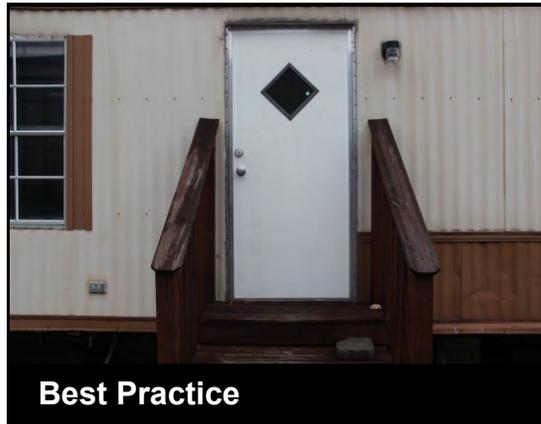
Objective(s):

Ensure replacement window or door operates properly

Ensure replacement window or door has a weathertight fit



Window is installed per manufacturer's specifications and adheres to local codes.



Door is installed to manufacturer's specifications and adheres to local codes.

3.1203.3e - Window and door installation



Door has a lockset that is easily operable from the inside without a key or special instruction.



Egress doors are the proper width for egress.



Egress doors are the proper height for egress.



Windows are the proper height for egress.



Windows are the proper width for egress.



Window sill height is within code guidelines.

3.1203.3f

Desired Outcome:

Smooth operation and an airtight and weathertight fit of replacement windows and doors

Specification(s):

Egress windows will only be replaced with egress windows

Objective(s):

Provide safe egress for occupants



Egress window in bedroom of manufactured house

Windows installed in egress (bedroom) windows must conform to the following standard: Voluntary Standard Egress Window Systems for Utilization in Manufactured Housing, AAMA 1704-85

3.1301.1d

Desired Outcome:

Penetrations sealed to minimize air leakage and moisture movement between unconditioned and conditioned space

Specification(s):

Combustion air supplies will be labeled for identification and will not be blocked or sealed

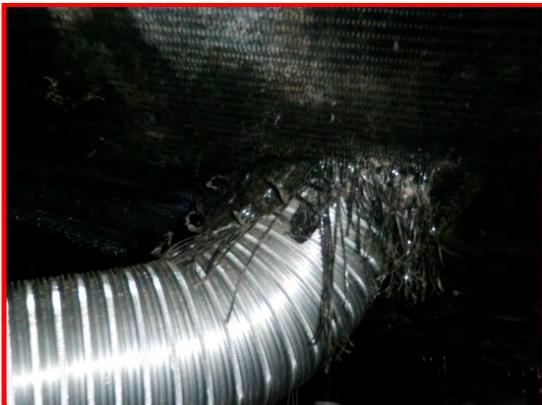
Penetrations will be sealed to meet both the specific characteristics of the bottom board material and the characteristics (hole size and type) of the penetrations (e.g., electrical, PVC, gas line, dryer vent)

The patch will not bend, sag, or move once installed

Objective(s):

Ensure combustion equipment is not compromised

Minimize air leakage around penetrations



 Before

Unsealed penetration through bottom board



 After

Properly sealed penetration through manufactured home bottom board

Tools:

1. Outward clinching (stitch) stapler
2. Utility knife
3. Cordless driver/drill
4. Reusable foam gun
5. Caulking gun
6. Nail gun

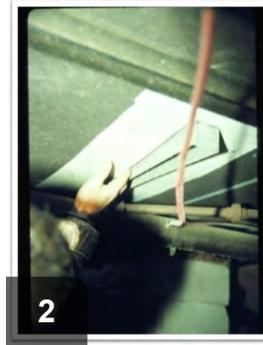
Materials:

1. Belly/bottom board fabric
2. Belly/bottom board repair tape
3. Staples
4. Screws
5. Foam board
6. 1X2 nailers
7. Spray foam sealant
8. High quality exterior caulk

3.1301.1d - Bottom board penetrations



Label combustion air inlets with the words, "DO NOT SEAL"



Seal around penetrations with compatible materials like foam board, belly board, house wrap, or Flex Mend (tm)

3.1301.2d

Desired Outcome:

Penetrations sealed to minimize air leakage and moisture movement between unconditioned and conditioned space; all repairs will maintain structural integrity

Specification(s):

Floor repair material will meet or exceed strength of existing floor material

Repair will span from joist to joist and blocking added as needed to support floor

Patches smaller than 144 square inches will not require repairs from joist to joist

Floor repair material will be glued, fastened, and air sealed

Objective(s):

Ensure floor is structurally sound

Minimize air leakage



 Before

Remove floor coverings from damaged area



 After

Completed floor repair

Tools:

1. Circular saw
2. Reciprocating saw
3. Caulking gun
4. Cordless driver/drill
5. Framing square
6. Speed square
7. Utility knife
8. Sawhorses
9. Clamps
10. Jig saw or keyhole saw
11. Paddle bits to drill starter holes in floor

Materials:

1. 5/8" or 3/4" oriented strand board or plywood subflooring
2. Polyurethane caulk
3. Construction adhesive
4. 2" deck screws
5. 3" deck screws
6. 8-penny galvanized ring shank or spiral shank nails
7. 16-penny galvanized ring shank or spiral shank nails
8. 2X4, or 2X6 blocking material for nailers
9. Air sealing foam (one- or two-part SPF)
10. Belly repair tape

Paddle bits may be used to drill starter holes at the corners of the area to be patched. Cut the new patch 1/4" shorter than the hole in both length and width to allow room for expansion and contraction. Make sure to cut the patch so that the strength axis is perpendicular to the joists (the strong direction in plywood and OSB is parallel to the 8' length).

3.1301.2d - Floor repair



1 Carefully remove trim and floor coverings from area to be repaired



2 Mark the joist locations on either side of the damaged area



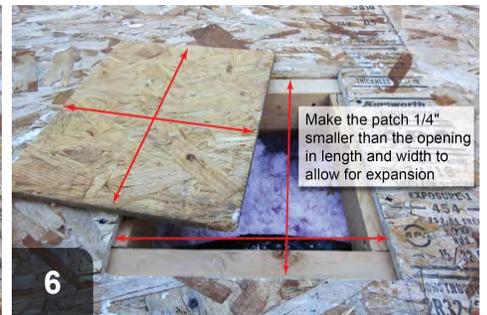
3 Cut out damaged area even with the inside edges of the floor joists



4 Cut four 2X4 blocks to support the patch



5 Install nailers flat against the joists. Finish by toenailing or screwing 2X4s between the joists



6 Make the patch 1/4" smaller than the opening in length and width to allow for expansion.



7 Apply subfloor adhesive to nailers



8 Fasten with 2" deck screws

3.1301.2e

Desired Outcome:

Penetrations sealed to minimize air leakage and moisture movement between unconditioned and conditioned space; all repairs will maintain structural integrity

Specification(s):

Materials will be selected to comply with manufactured housing rules and regulations (e.g., Manufactured Housing Institute)

Materials will be used or installed in accordance with manufacturer specifications

Objective(s):

Select materials to ensure durable and permanent repair



Use materials with sufficient strength to span openings and support repair materials without bending or sagging

Tools:

1. Screw gun
2. Drill
3. Circular saw
4. Hammer or nail gun

Materials:

1. Typically 1X2, 1X4, 2X4, or 2X6 dimensional lumber. Steel angle may also be used to create sturdy repairs
2. Nails
3. Screws
4. Nuts, bolts, and washers
5. Staples

3.1601.5a

Desired Outcome:

Ducts and plenums properly fastened to prevent leakage

Specification(s):

Surrounding insulation will be cleared to expose joints being sealed; salvage for reuse if possible

Duct surface to receive sealant will be cleaned

Objective(s):

Gain access while maintaining insulation value

Achieve proper adhesion for airtight seal when needed to ensure a tight fit to the framing structure and ensure the register can be removed and reinstalled by the dwelling occupant



Before

Locate disconnected or damaged ducts and clean work area of debris



In Progress

Clean surfaces to receive sealant. Allow to dry before applying sealant

Materials:

1. Cleaning solution or cleaning wipes

3.1601.5b

Desired Outcome:

Ducts and plenums properly fastened to prevent leakage

Specification(s):

Ducts will be fastened with a minimum of three equally spaced screws

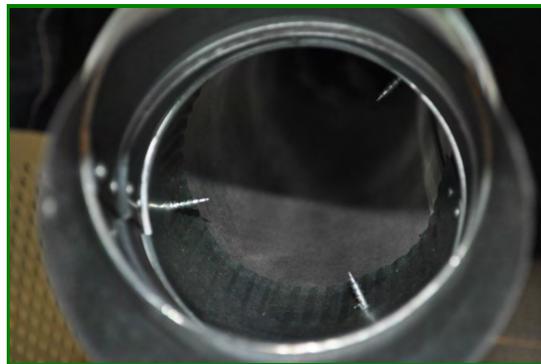
Objective(s):

Ensure durable joints



 Before

Reconnect ducts that have come undone, using fasteners to strengthen connection



 After

At minimum, use three fasteners evenly spaced

Tools:

1. Drill

Materials:

1. Fasteners

3.1601.5c

Desired Outcome:

Ducts and plenums properly fastened to prevent leakage

Specification(s):

Joints will be fastened with tie bands using a tie band tensioning tool

For oval flexible duct to metal connections, tie bands cannot be used; appropriate mechanical fastener will be used

All connections, regardless of fastener, will be sealed

Objective(s):

Ensure durable joints



 Before

Disconnected ducts are useless and need to be reconnect and securely fastened



 After

Flexible duct should be securely fastened to metal ducting to prevent future dislocation and minimize leakage

Tools:

1. Band tensioner
2. Brush

Materials:

1. Tie bands
2. Mastic or other appropriate sealant

3.1601.5c - Flex to metal



1 Apply mastic to flange



2 Slide inner liner onto flange with sealant



3 Using band tensioner, securely attach liner in place with tie band



4 Slide insulation and outer casing over metal ducting



5 Extend insulation and casing until in contact with other insulation



6 Secure insulation and casing in place using tie band and band tensioner

3.1601.5e

Desired Outcome:

Ducts and plenums properly fastened to prevent leakage

Specification(s):

Metal take-off collar specifically designed for the thickness of the duct board will be used

All finger tabs will be bent down securely

Finger tabs will be longer than the thickness of the duct board and the shank will not extend beyond the thickness of the duct board

There will be an internal metal backer inside the duct board through which three evenly spaced screws can be secured; the metal backer will not interfere with air flow

Objective(s):

Ensure durable joints

Prevent the collar from moving into or out of the duct board or slipping



Bad Practice

Flex duct improperly attached to duct board.
No starting collar is installed.



Best Practice

Flex duct, starting collar, and backer ring installed and sealed to duct board

Tools:

1. Cordless driver/drill
2. 1/4" nut driver bit
3. Disposable brushes
4. Tin snips
5. Utility knife
6. Zip tie tensioning tool

Materials:

1. Galvanized metal backer rings
2. Tabbed starting collars
3. Rubber gloves
4. Zip ties
5. Duct sealing mastic
6. Fiberglass mesh tape

Make sure to use a starting collar that is made for the thickness of the duct board you are using. R-6 duct board is 1-1/2" thick. The correct starting collar would therefore have 1-1/2" of solid metal between the shoulder that fits against the outside of the duct board and the base of the tabs.

You may need to cut a slot in the duct board to slide the backer ring through. Use at least three equally spaced screws to fasten the starting collar to the backer ring.

3.1601.5e - Duct board to flexible duct



1 Gather materials



2 Place backer ring inside duct board. Insert collar and bend tabs into place.



3 Fasten the collar to the backer ring by driving at least three equally spaced screws through the collar, duct board



4 Coat joint between starting collar and duct board with mastic. Liberally coat the metal collar where flex attaches



5 Slide flex duct liner over mastic-coated metal collar



6 Secure with properly tensioned zip tie.



7 Coat seam with mastic



8 Pull insulation over duct liner and secure with a zip tie.

3.1601.5f

Desired Outcome:

Ducts and plenums properly fastened to prevent leakage

Specification(s):

Flange/c-channel will be fastened with screws with the duct board installed between c-channel flanges

Duct board plenum will be connected to air handler plenum with flexible duct in upflow units

Objective(s):

Ensure durable joints



Duct board plenum fastened with C-channel and screws

Tools:

1. Screw gun
2. Tin snips
3. Utility knife
4. Tape measure
5. Square

Materials:

1. Fiberglass duct board
2. C-channel (same width as duct board)
3. Sheet metal screws longer than the duct board thickness
4. Foil tape (for assembling duct board)
5. Mastic
6. Mesh tape (for gaps larger than 1/4")
7. Flex duct
8. Zip ties
9. Starting collar
10. Backing ring (fits inside duct board and fastens to starting collar)

3.1601.5g

Desired Outcome:

Ducts and plenums properly fastened to prevent leakage

Specification(s):

Predrill for screws or use ring shanked nails to fasten boot to wood

Objective(s):

Ensure durable joints



Unattached ducts are useless



Damaged ducts should be repaired and securely fastened and sealed

Tools:

1. Drill
2. Hammer

Materials:

1. Metal screws
2. Ring-shank nails

3.1601.5g - Boot to wood



1 Replace damaged ducting if necessary



2 Use ring-shank nails to hold ducting in place to subfloor



3 Drill pilot holes for metal fasteners



4 Use metal fasteners to secure duct to subfloor



5 After securely fastened, duct should be sealed with mesh and mastic

3.1601.5h

Desired Outcome:

Ducts and plenums properly fastened to prevent leakage

Specification(s):

If accessible, boot hanger will be fastened to adjacent framing with screws or nails

Boot will be connected to boot hanger with screws

If inaccessible, boot will be fastened to gypsum with a durable, adhesive sealant

Objective(s):

Ensure durable joints



Register boot fastened to framing and sealed to gypsum with spray foam

Tools:

1. Caulking gun or foam gun
2. Cordless driver/drill

Materials:

1. Polyurethane caulk
2. Mastic and mesh tape (for gaps larger than 1/4")
3. Screws
4. Fiberglass mesh tape (for gaps larger than 1/4")
5. Disposable brushes
6. Spray foam sealant

Fasten boot hangers to adjacent framing, or screw through the boot into adjacent framing. Polyurethane caulk is a durable adhesive, and can accommodate up to 50% expansion and

contraction. Mastic and mesh tape also form a strong, permanent seal. Spray foam may be used to seal boots into the opening once the boot is fastened in place

3.1601.5h - Boot to gypsum



Remove diffuser



Caulk the boot to the gypsum board. Angle the tip forward and force caulk into the joint



Wipe the caulk into the joint and smooth it as you go



Wipe away excess caulk (use water on siliconized acrylic, alcohol on silicone, and solvent on polyurethane caulk)

3.1602.8b

Desired Outcome:

Deliver all air from air handler to the trunk duct without leakage or restriction

Specification(s):

Debris will be removed

Surface will be prepared for work (e.g., remove tape, oil)

Floor will be prepared to receive the appropriately sized plenum

Objective(s):

Provide unobstructed path for work access and air flow

Ensure adhesion of materials to be installed

Provide a properly sized plenum to maximize distribution of air flow (equal to the furnace discharge)



Closet prepared for furnace installation

Tools:

1. Shop vac
2. Scraper
3. Bench duster
4. Dust pan

Materials:

1. Rags

3.1602.8b - Preparation



Dust walls and floor of cabinet. Sweep debris into piles for pickup. Wipe down walls and floor



Vacuum cabinet clean



Inspect plenum for damage, then clean, scrape, and seal



Scrape loose material from insides of cabinet



Apply mastic to inside seams of plenum

3.1602.8c

Desired Outcome:

Deliver all air from air handler to the trunk duct without leakage or restriction

Specification(s):

Plenum will be rebuilt or repaired using compatible materials and will be:

- Mechanically fastened
- Sealed
- Durable
- Structurally sound
- Insulated
- Equipped with a vapor retarder where climate appropriate

If possible, flow diverter or turning vanes will be installed for air flow and/or balancing (e.g., bullhead Ts, offset air handler)

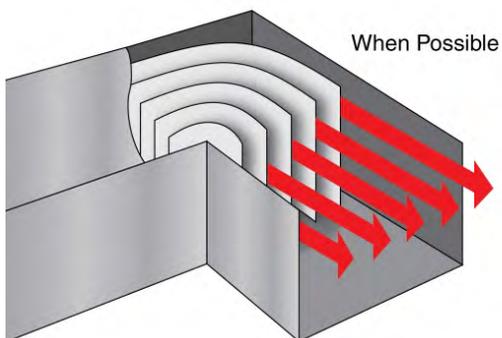
Objective(s):

Minimize restrictions

Maximize air flow and air distribution

Minimize moisture issues

Prevent condensation on plenum



Best Practice

Whenever possible, install turning vanes in plenums to reduce turbulence and improve airflow



In Progress

Rebuilding and sealing a leaky existing plenum

Materials:

1. Starting collars and flanges
2. Zip ties
3. Mastic duct sealant
4. Fiberglass mesh tape
5. Sheet metal screws
6. Turning vanes
7. Duct board

Using turning vanes reduces turbulence and increases air flow. Use mastic and mesh tape on the outside of duct board plenums. Properly install metal starting collars to duct board and flex duct to metal collars (see spec 3.1601.5e for detail)

3.1602.8d

Desired Outcome:

Deliver all air from air handler to the trunk duct without leakage or restriction

Specification(s):

Point of access options include:

Option 1: Through the trunk duct

- Repair and seal access hole in the trunk duct
- Install insulation
- Repair belly/bottom liner

Option 2: Remove crossover duct

- Reattach crossover duct
- Seal and insulate crossover duct
- Repair belly/bottom liner

Option 3: Remove air handler

- Install new gasket, if necessary
- Mechanically attach furnace to the structure
- Reconnect utilities
- Replace and seal panels

Option 4: Through the furnace panel

- Replace and seal panels

Objective(s):

Repair work access

Prevent condensation

Minimize heat loss and heat gain from plenum



Various methods can be employed, but the key is to seal the furnace to trunk duct connection

Tools:

1. Utility knife
2. Saw
3. Prybar
4. Screw gun
5. Hammer
6. Drill
7. Saw
8. Disposable brushes

Materials:

1. Belly repair tape
2. Mastic duct sealant
3. Fiberglass mesh tape
4. Insulation
5. Air handler gasket

Choose the least invasive and labor-intensive method that will allow full access for sealing.

Always wear hand protection when working with sharp objects.

3.1602.8d - Repair work access



Cut belly to expose duct trunk. Use a utility knife to cut access under furnace plenum



Create an opening large enough to completely seal the plenum to the trunk line



Using mastic and mesh tape, fully seal the furnace to the trunk line. Repair and seal the access holes in duct and belly



Removing the crossover duct may provide access to the plenum. Replace and seal the crossover duct after sealing plenum



Remove the furnace panel. If the plenum to trunk connection is accessible here, complete sealing from this point



Plenum to duct trunk connection coated with mastic sealant

3.1602.8e

Desired Outcome:

Deliver all air from air handler to the trunk duct without leakage or restriction

Specification(s):

Equipment will be cycled

Combustion Appliance Zone (CAZ) test will be performed where combustion appliances are utilized

Objective(s):

Verify operation

Identify unsafe equipment operating conditions

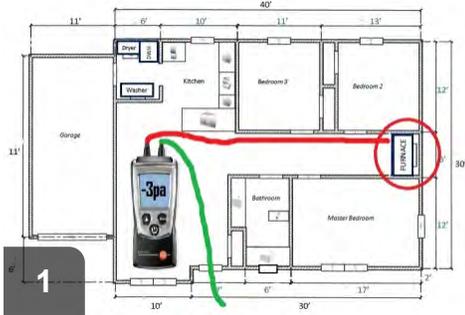


Conduct spillage and depressurization testing at the end of the work day

Tools:

1. Manometer
2. Smoke pencil
3. Mirror
4. Stopwatch or watch with second hand

3.1602.8e - Safety testing



1 Run depressurization test at the end of the work day



2 Complete spillage test using chemical smoke pencil or mirror



3 Test for spillage on all sides of draft diverter. Check spillage on all atmospheric combustion appliances



4 Check carbon monoxide levels on all combustion appliances, including direct vent equipment



5 Check carbon monoxide levels on all combustion appliances

3.1602.8f

Desired Outcome:

Deliver all air from air handler to the trunk duct without leakage or restriction

Specification(s):

Pre- and post-retrofit duct leakage will be performance tested using a duct blaster or pressure pan, and results will be documented and reported to the homeowner and/or program

Objective(s):

Document post-retrofit duct leakage test has been performed



Best Practice

Test duct performance using pressure pan or duct blaster, before and after work



Best Practice

Record readings before and after to determine improvement in performance

Tools:

1. Duct blaster
2. Blower door
3. Manometer
4. Pressure Pan

Materials:

1. Duct mask

3.1602.8f - Performance testing



Perform duct blaster testing before beginning work. Record results



Perform duct blaster testing after completion of work and compare to 'before' reading. Record results



Set-up blower door to perform pressure pan testing before and after work



Perform pressure pan test on ductwork before beginning work. Record result



Perform pressure pan test after work is completed and compare to 'before' reading



Record test results to determine improvement of performance

3.1602.9h, 3.1602.10f, 3.1602.11d, 3.1602.12c

3.1602.9a

Desired Outcome:

Deliver all air from trunk to trunk without leakage or restriction

Specification(s):

Installer prework assessment will be conducted to determine:

- Location
- Types
- Leakage points

Objective(s):

Verify scope of work



Locate the best access and egress points



Locate crossover duct and determine what type of system will work best for home

3.1602.9b

Desired Outcome:

Deliver all air from trunk to trunk without leakage or restriction

Specification(s):

Flexible crossover duct connections will be added, rebuilt, or repaired using compatible materials and will be:

- Mechanically fastened at both inner and outer liner
- Sealed using UL-listed sealant that is durable, structurally sound, insulated
- Equipped with a vapor retarder

Whenever possible, rigid elbow or equivalent will be installed in crawl space crossover ducts

Floor insulation will be in contact with the outer liner of the crossover duct

Crossover duct vapor retarder will be sealed to the bottom liner (e.g., belly fabric)

New flex duct installation will be insulated to a minimum of R-8

When feasible, 26-gauge hard duct should be installed

If a new crossover is required, it must be insulated to at least R-8 and be air sealed

Objective(s):

Ensure lasting durable connections

Minimize air leakage and heat transfer

Maintain duct diameter around the turns

Maximize air flow and distribution



 Before

Unattached ducts are useless



 After

Crossover ducts should be attached securely, sealed to reduce leakage, and insulated to R-8

Tools:

1. Band tensioner
2. Drill
3. Brush

Materials:

1. Tie bands
2. Mastic or other appropriate sealant
3. 26 gauge elbow duct
4. R-8 insulated flexible duct with vapor retarder

3.1602.9b - Flexible crossover duct connections



1 Attach elbow duct and orient in correct direction to minimize duct run



2 Fasten elbow in place with at least three evenly-spaced fasteners



3 Apply mastic at metal-to-metal connection



4 Apply mastic to all elbow joints and flange



5 Slide inner liner onto flange with sealant



6 Fasten inner inner with tie band using band tensioner



7 Extend insulation and exterior casing up over elbow until they reach belly



8 Secure insulation and outer casing in place with tie band



9 Use band tensioner to ensure that insulation and casing remain tight against belly

3.1602.9c

Desired Outcome:

Deliver all air from trunk to trunk without leakage or restriction

Specification(s):

Crossover ducts will be installed so they are not in contact with the ground

Crossover ducts will be supported in accordance with flex duct manufacturer specifications, local codes

Support materials will be applied in accordance with manufacturer specifications for interior dimensions and will not crimp ductwork, dip, or sag

Objective(s):

Maximize air flow and distribution

Minimize condensation

Minimize air leakage and heat transfer



 Before

Flexible ducting should not come in contact with ground



 After

Supports should be evenly spaced, securely fastened to floor joists and should not compress or kink duct

Tools:

1. Drill
2. Utility knife

Materials:

1. Fabric straps
2. Fasteners

3.1602.9g

Desired Outcome:

Deliver all air from trunk to trunk without leakage or restriction

Specification(s):

CAZ testing will be performed where combustion appliances are utilized

Objective(s):

Identify unsafe equipment operating conditions



Complete combustion appliance zone testing to ensure a healthy, safe environment

See
**SWS 2.0201.3a-
2.0201.3h
for CAZ testing**

Tools:

1. Manometer
2. Mirror
3. Chemical smoke puffer
4. Stopwatch or watch with second hand
5. Gas leak detector
6. Combustion analyzer
7. 1/4" air line tubing

At the end of each day in which duct sealing or repair is performed, conduct Combustion Appliance Zone (CAZ) testing in accordance with the NREL Manufactured Home Standard Work Specifications, details 2.0201.3a through 2.0201.3h.

3.1602.10c

Desired Outcome:

Deliver air from trunk to termination (register/diffuser) without leakage

Specification(s):

Hard and flex duct branch connections will be rebuilt or repaired using compatible materials and will be mechanically fastened and sealed

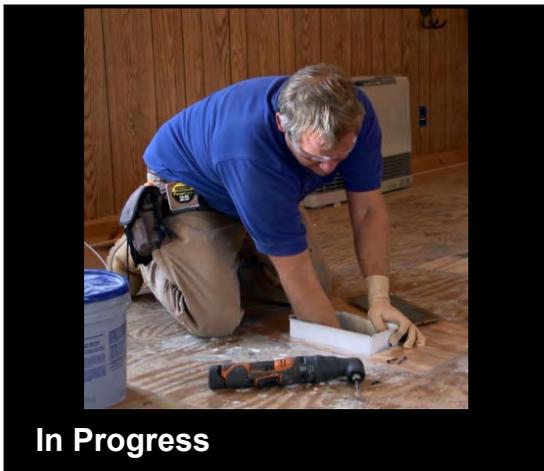
Ends will be sealed

Objective(s):

Ensure lasting durable connections

Minimize air leakage

Maximize air flow and distribution



Here the worker is rebuilding a hard connection to the trunk line.



The duct has been sealed, ensuring proper airflow to the home.

Tools:

1. drill
2. tin snips
3. inspection mirror
4. utility knife

Materials:

1. metal boot material
2. mesh tape
3. mastic
4. replacement grille

3.1602.10c - Duct connection repairs



Measure the dimensions required for the new boot.



Fit the new boot on to the trunk line.



Seal the boot to the trunk line using mastic and mesh tape. An inspection mirror can make this easier.



Mechanically fasten the boot to the subfloor.



Install a new grille on the rebuilt boot.

3.1602.10d

Desired Outcome:

Deliver air from trunk to termination (register/diffuser) without leakage

Specification(s):

Access hole in the trunk/branch duct will be repaired and sealed

Insulation will be reinstalled

Bottom liner/belly will be repaired

Objective(s):

Repair work access

Minimize heat transfer



 Before

Access hole cut into manufactured home branch duct



 After

Repaired, insulated, and sealed access hole in manufactured home duct and belly

Tools:

1. Utility knife
2. Disposable brushes
3. Outward clinching stapler
4. Scissors

Materials:

1. Fiberglass mesh tape
2. Mastic duct sealant
3. Foil tape
4. Insulation
5. Belly repair tape
6. Belly wrap
7. Staples
8. Solvent (acetone, paint thinner, denatured alcohol, Goof-Off, or similar) to clean aluminum duct
9. Spray adhesive for belly repairs

3.1602.10d - Repair work access



Thoroughly clean duct with solvent before applying foil tape and mastic



Secure edges of repair with foil tape and then liberally coat with mastic



Overlap foil tape with mastic by at least one inch on all sides



Replace or reinstall fiberglass belly insulation



Apply belly repair tape and fasten with outward clinching (stitch) staples. Spray adhesive will help adhere the tape

3.1602.10e

Desired Outcome:

Deliver air from trunk to termination (register/diffuser) without leakage

Specification(s):

CAZ testing will be performed where combustion appliances are utilized

Objective(s):

Identify unsafe equipment operating conditions



Complete combustion appliance zone testing to ensure a healthy, safe environment

Tools:

1. Manometer
2. Mirror
3. Chemical smoke pencil
4. Gas leak detector
5. Combustion analyzer
6. Stopwatch
7. 1/4" air line tubing

At the end of each day in which duct sealing or repair is performed, conduct Combustion Appliance Zone (CAZ) testing in accordance with the NREL Manufactured Home Standard Work Specifications, details 2.0201.3a through 2.0201.3h.

See
**SWS 2.0201.3a-
2.0201.3h**
for CAZ testing

3.1602.11a

Desired Outcome:

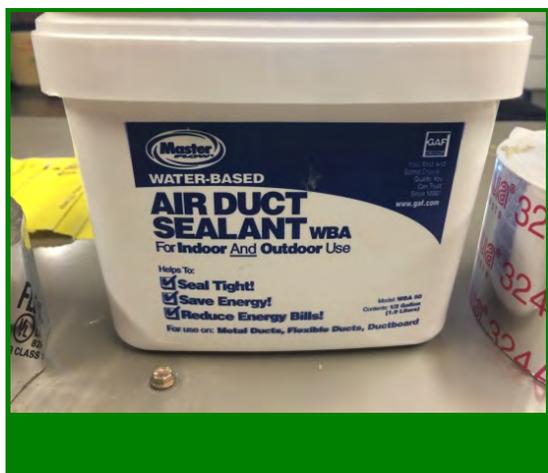
Ducts and plenums sealed to prevent leakage

Specification(s):

Any closure system used will meet or exceed applicable standards

Objective(s):

Ensure effectiveness of air sealing system



Mastic sealant is an approved, durable, and effective sealant

Tools:

1. Utility knife
2. Disposable brushes

Materials:

1. UL 181 B-FX tape (cover with mastic after assembly)
2. Fiberglass mesh tape (use, along with mastic, to cover gaps wider than 1/4-inch and to add strength to assemblies)
3. Mastic (air duct sealant) labeled UL 181 B-M

Use tape labeled 181 B-FX and/or mastic labeled 181 BM. Seal and mechanically fasten all duct connections to metal flanges. Fasten round metal ducts with at least three screws equally spaced around the diameter, and make sure that the ducts and fittings are inserted at least 1". DO NOT USE unlisted duct tape as a sealant on any duct.

Exceptions:

1. Spray polyurethane foam shall not be permitted to be applied to ductwork.

2. Where a duct connection is made that is partially inaccessible, three screws or rivets shall be equally spaced on the exposed portion of the joint so as to prevent a hinge effect.
3. Continuously welded and locking-type longitudinal joints and seams in ducts operating at static pressures less than 2 inches of water column (500 Pa) pressure classification shall not require additional closure systems. "

3.1602.11a - New component to new component sealant selection



Use fiberglass mesh tape to cover gaps; coat with at least 2mm of mastic



Coat seams with mastic (air duct sealant) conforming to standard UL 181 B-M



Use tape to assemble joints, then coat with at least 2mm of mastic

3.1602.11b

Desired Outcome:

Ducts and plenums sealed to prevent leakage

Specification(s):

Duct surface to receive sealant will be cleaned

Seams, cracks, joints, holes, and penetrations less than ¼" will be sealed using fiberglass mesh and mastic

Mastic alone will be acceptable for holes less than ¼" that are more than 10' from air handler

Holes greater than ¾" will be patched with metal or joint will be rebuilt to reduce the gap size

Seams, cracks, joints, holes, and penetrations between ¼" and ¾" will be sealed in two stages:

- They will be backed using temporary tape (e.g., foil tape) as a support before sealing
- They will be sealed using fiberglass mesh and mastic

Objective(s):

Eliminate air leakage into or out of ducts and plenums

Ensure adhesion of primary seal (fiberglass mesh and mastic) to the duct

Reinforce seal

Support mastic and fiberglass mesh during curing



 Before

Unsealed metal ductwork



 After

Mastic and mesh tape used to seal metal ductwork

Tools:

1. Zip tie tensioning tool
2. Utility knife
3. Disposable brushes
4. Tin snips
5. Screw gun

Materials:

1. Mastic
2. Fiberglass mesh tape
3. Metal starting collar
4. Foil tape
5. Sheet metal

3.1602.11b - New component to existing component



1
Fasten collar into plenum with screws that reach through the tabs and plenum into a backing ring. Apply mastic liberally



2
Apply mastic to metal collar



3
Install duct liner onto collar and secure with properly tensioned zip tie



4
Apply additional mastic over zip tie and edge of flex duct liner

3.1602.11c

Desired Outcome:

Ducts and plenums sealed to prevent leakage

Specification(s):

Duct surface to receive sealant will be cleaned

Fiberglass mesh and mastic will overlap temporary tape by at least 1" on all sides

Seams, cracks, joints, holes, and penetrations larger than $\frac{3}{4}$ " will be repaired using rigid duct material

Fiberglass mesh and mastic will overlap repair joint by at least 1" on all sides

Fiberglass mesh and mastic will be the primary seal

Objective(s):

Eliminate air leakage into or out of ducts and plenums

Ensure adhesion of primary seal (fiberglass mesh and mastic) to the duct

Reinforce seal

Support mastic and fiberglass mesh during curing



Before

Unsealed joints and connections need to be sealed to stop air leaks, improve durability, and minimize health risks



After

Sealed ductwork connections help prevent leakage

Tools:

1. Brush

Materials:

1. Mastic
2. Fiberglass mesh tape

3.1602.11c - Existing component to existing component



1 Prepare work area by assessing any safety concerns and cleaning duct surface



2 Wrap joint with fiberglass mesh tape



3 Apply UL 181 mastic to seal joint

3.1602.12a

Desired Outcome:

Ducts and plenums sealed to prevent leakage

Specification(s):

Gaps between boot and gypsum less than a 1/4" will be sealed using mastic or appropriate flexible caulking

Gypsum edge will be wetted before applying mastic

Objective(s):

Prevent air leakage



 Before

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



 After

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

Tools:

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

Materials:

1. Mastic
2. Fiberglass mesh tape

3.1602.12a - 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

3.1602.12b

Desired Outcome:

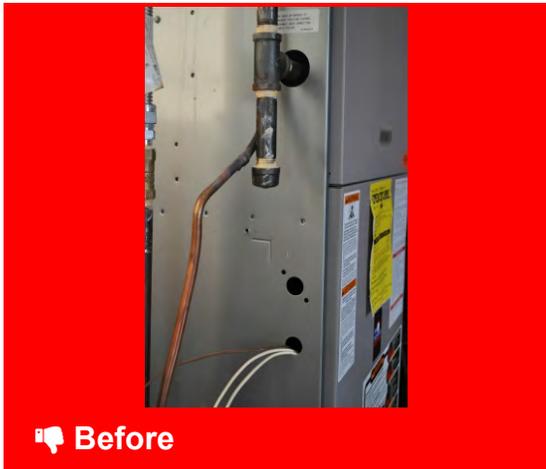
Ducts and plenums sealed to prevent leakage

Specification(s):

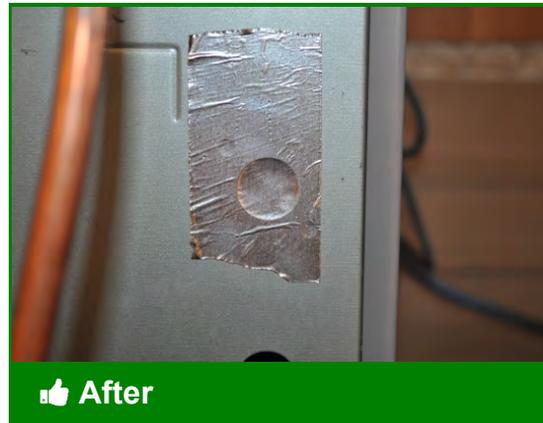
Joints will be sealed and cracks/holes not needed for proper function of unit will be sealed using removable sealant (e.g., foil tape)

Objective(s):

Reduce air leakage while maintaining accessibility



Unnecessary holes in the air handler cabinet need to be sealed



Use removable foil tape to seal holes

Materials:

1. Foil tape

3.1602.12b - Air handler cabinet outside conditioned space



1
Unnecessary holes in the air handler cabinet should be sealed



2
Removable foil tape should be used to seal



3
Fully cover holes with tape to seal completely

3.1602.13a

Desired Outcome:

The return duct is 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



Before

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



In Progress

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

Tools:

1. Shop vacuum

3.1602.13b

Desired Outcome:

The return duct is 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 all loads (e.g., return air pressure)

Ensure sealant does not fall out



Before

Leakage from air return into wall cavities should be eliminated



In Progress

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

Tools:

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

Materials:

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

3.1602.13b - Infill and backing



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

3.1602.13c

Desired Outcome:

The return duct is installed to prevent air leakage

Specification(s):

Sealants will be compatible with their intended surfaces

Sealants will be continuous and meet fire barrier specifications

Objective(s):

Select permanent sealant

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



Best Practice

Sealants, like mesh and UL 181 mastic, meet IRC, ASTM, and UL specs



Best Practice

Caulk sealants will be continuous and compatible with surface

Tools:

1. Caulk gun
2. Utility knife
3. Taping knife

Materials:

1. Fiberglass mesh
2. Siliconized caulk
3. UL 181 mastic

Wall and ceiling finishes will have a flame spread index of 200 or less and a smoke-developed index of 450 or less

4.1003.8a

Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

All combustion appliance flues will be terminated to the outdoors and terminations will maintain proper clearance above snow loads

A distance no less than 2" will be maintained between any combustion appliance flue and combustible materials, unless zero clearance flue is in place

All ventilation systems will maintain a continuous connection and terminate to the outdoors

All broken mushroom vents will be replaced or removed and sealed

All plumbing stacks will be terminated to the outdoors

Non-IC rated light fixtures will be replaced with airtight IC-rated fixtures

All recessed lights will be labeled as having an air leakage rate no more than 2.0 CFM when tested in accordance with ASTM E 283 at a 75 pascals pressure differential

All obvious ceiling penetrations will be sealed

The space between combustion appliance flues and the ceiling will be sealed with fire-rated materials

All roof, attic, and ceiling assemblies will be structurally sound; loose ceiling panels will be secured

Temporary ceiling bracing will be recommended during the insulation installation process

Dishing and pooling issues that allow standing water will be addressed

All known roof water leaks will be repaired before insulation installation

Objective(s):

Ensure occupant and worker safety

Verify attic space is ready to insulate

Ensure structural integrity of the roof and ceiling assembly

Prevent intrusion of bulk moisture

Prevent damage during the insulation installation process



Roof leak, missing cap on vent



Properly connected and sealed roof vent

Tools:

1. Scaffolding and ladders
2. Screw gun
3. Long, flat prybar
4. 5-in-one paint scraper tool
5. Flashlights and headlamps
6. Digital camera

Materials:

1. Wooden blocks

Inspect and correct each of the specified items: flues terminated to outside, 2" clearance to combustibles from flues, ventilation ducts terminated outdoors, non-airtight, non-IC rated recessed lighting replaced with airtight, IC-rated recessed units, broken mushroom vents replaced or removed, plumbing vents terminated outdoors, ceiling penetrations sealed, structural defects in roof, attic, and ceiling assemblies corrected, ponds on roof remedied, and all roof leaks repaired.

4.1003.8a - Attic, ceiling, and roof verification



Inspect roof for evidence of water pooling, leaks, or damage. Verify proper vent terminations



Inspect ceiling for weakness, leaks, clearance to combustibles, loose panels, and penetrations



Verify presence of rain caps on all vents



Inspect all patches and repairs, and correct deficiencies if necessary



Verify at least 2" clearance to combustibles, unless flue is designed for zero clearance. Repair if needed



Use temporary supports to avoid ceiling collapse during insulation install



Add fasteners wherever needed to firmly attach ceiling to the trusses



Investigate all water stains and sources of moisture. Repair before insulating the attic



After opening the roof edge, verify proper clearance to combustibles and inspect vent connections

4.1003.8b

Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

Fasteners will be removed from the J channel and the roof edge on the most easily accessible side of the house

Roof will be separated from the heel plate and siding roof will be lifted and propped to accommodate fill tube

Length of opening will be enough to allow ease of access and reattachment while minimizing potential damage from high winds

If subsheathing is present, access will be gained through subsheathing

Attic will be visually inspected for the location of existing insulation, obstructions, hazards, and construction type

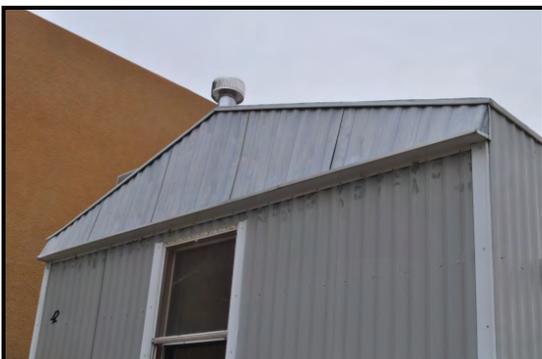
Objective(s):

Create access to the full attic cavity

Protect roof from wind damage during installation

Ensure ease of roof reattachment

Determine insulation installation technique



Best Practice

Pitched, bowed, and vaulted roofs are good candidates for insulation via roof side lift



Best Practice

Insulation can be installed without disturbing the interior environment

Tools:

1. Pry bar
2. Drill
3. Utility knife
4. Pliers

Materials:

1. Wood blocks

4.1003.8b - Attic access



1
Ensure a safe work environment by setting up scaffolding. Work in manageable sections



2
Remove fasteners from the J-channel



3
Cut through putty tape and pry J-channel away from roof seam



4
Work in manageable sections to minimize roof damage. One section of J-channel is a long enough area



5
Remove staples as necessary to lift roof and inspect underneath



6
Place blocks to lift roof and enable inspection of roof cavity for obstructions and other concerns



7
Work in small sections to minimize flexing of roof and risk of wind damage



8
Once visual inspection has shown roof cavity to be viable, begin blowing insulation

4.1003.8c

Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

Blowing machine pressure test will be performed with air on full, feed off, and gate closed

Hose outlet pressure will be set in accordance with manufacturer specifications

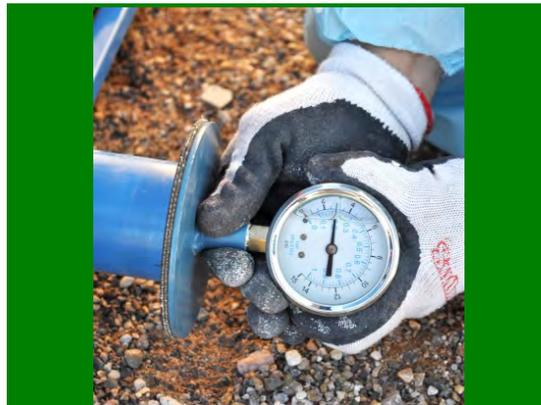
Objective(s):

Ensure machine is capable of delivering uniform insulation density and coverage



In Progress

Before loading insulation, check to ensure that machine is operating properly



Best Practice

Test insulation blowing machine's pressure to ensure it is operating within manufacturer's parameters

Tools:

1. Hex wrench
2. Pressure gauge

4.1003.8c - Blowing machine set up



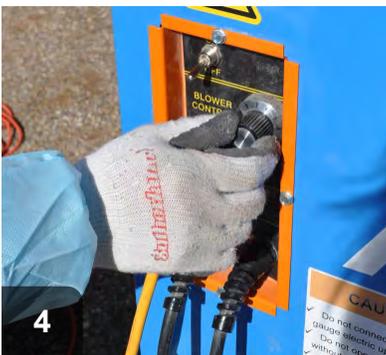
Set-up blowing machine on dry, level surface near electrical source and insulation site



Check electrical connections before operation



Make sure feed is off for testing and gate is closed



Adjust blower to full, or maximum



Using pressure gauge at feed outlet, verify that machine is working within manufacturer's specifications



If testing shows machine is operating properly, attach hose and tighten fitting to minimize slippage



Open gate to allow for feed of insulation, turn on feed

4.1003.8d

Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

Insulation will be installed to a density of 1.5 to 1.6 pounds per cubic foot

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

Fill tube will be inserted within 6" of the end of each attic cavity

Insulation will be installed into the void of the attic cavity:

- If existing insulation is roof-mounted, insulation will be blown below
- If existing insulation is ceiling-mounted, insulation will be blown above
- If existing insulation is mounted at both locations, insulation will be blown in between

Avoid overfilling of roof edges and above attic trusses

Flame spread and smoke-developed index for insulation will be a flame spread rating of 25 or less and a smoke development rating of 450 or less when tested in accordance with ASTM E84

Objective(s):

Fill entire attic cavity to the prescribed R-value to reduce air infiltration

Avoid clogging of the cavity and the fill tube

Prevent damage to the ceiling

Allow roof to be returned to original position

Fire safety will be maintained

4.1003.8d - Fiberglass blown insulation installation



If insulation is roof mounted, blow below it.



If insulation is ceiling mounted, blow above it.



If insulation is mounted at both the ceiling and the roof, blow between it.



Insulation meets ASTM E 84.

4.1003.8e

Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

If existing J channel is damaged, it will be replaced

Existing sealant will be removed from the roof edge and J channel

At a minimum, new sealant will be reinstalled at the original location

Roof and J channel will be fastened to the original location with new screws

All seams, edges, and penetrations will be sealed as necessary

Objective(s):

Prepare roof edge and J channel for reattachment

Reattach roof edge and J channel without leaks



Before

If salvageable, clean J-channel before reinstallation



After

Attach J-channel using old holes and new fasteners

Tools:

1. Drill
2. Utility knife
3. Snips

Materials:

1. Fasteners
2. J-channel
3. Putty tape

4.1003.8e - Roof reattachment



If J-channel is salvageable, clean thoroughly before applying putty tape



Apply putty tape to new or reused J-channel to seal roof seam



Using new fasteners, attach J-channel along roof seam and seal as necessary

4.1003.8f

Desired Outcome:

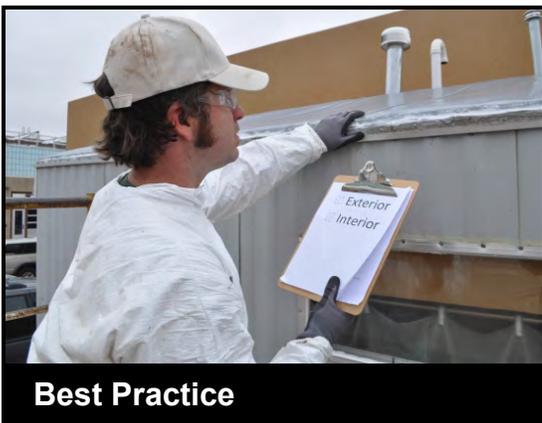
Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

Installation process will be considered complete when installer has verified that damage has not occurred to the roof or ceiling assemblies during the installation process

Objective(s):

Verify the integrity of the house has been maintained



Best Practice

Exterior should be inspected to verify that roof has not been damaged



Best Practice

Interior ceiling should also be inspected to make sure that no damage was incurred

4.1003.9a - Attic, ceiling, and roof verification



1 Photo: Cal Steiner
Inspect roof for evidence of water pooling, leaks, or damage. Verify proper vent terminations



2
Inspect all patches and repairs, and correct deficiencies if necessary



3
Verify presence of rain caps on all vents



4 Photo Credit: Cal Steiner
Inspect ceiling for weakness, leaks, clearance to combustibles, loose panels, and penetrations



5
Verify at least 2" clearance to combustibles, unless flue is designed for zero clearance. Repair if needed



6 Photo: Cal Steiner
Repair and refasten sagging or unsecured ceiling panels. Caulk and seal seams to prevent insulation spilling into house



7
Use temporary supports to avoid ceiling collapse during insulation install

4.1003.9b

Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

Access to the attic cavity will be created using one of these methods:

- Drilling
- Cutting
- Continuous slicing along the center line (at the highest point of the roof)

Access location will be placed to allow for consistent and uniform coverage of installed insulation throughout the attic assembly

There will be, at a minimum, one opening between each roof truss

Openings will be large enough to accommodate the chosen fill tube

If subsheathing is present, access will be gained through subsheathing

Attic will be visually inspected for the location of existing insulation, wiring, flues, obstructions, hazards, and construction type

Objective(s):

Create access to the full attic cavity

Maintain the integrity of the roof truss

Protect roof from wind damage during installation

Determine technique for installing insulation



In Progress

Manufactured home attic access by slicing along ridgeline

Tools:

1. 7-1/4" circular saw
2. Electric drill
3. Carbide-tipped hole saw bits
4. Insulation blowing machine
5. 2" PVC pipe, 10 feet long
6. 4-1/2" or 7" angle grinder with flexible sanding wheels
7. Tape measure and chalk lines
8. Scaffolding

Materials:

1. Abrasive or carbide-toothed cutting wheels

If attic has both flat and vaulted ceilings, access may be gained through the gable ends for the flat ceilings.

Always use hand protection when working with metal edges and/or sharp tools.

4.1003.9b - Attic access



Determine and mark truss locations on roof, and choose method of access. Avoid drilling or sawing into trusses



Option 1: Drill a 4" hole in each truss cavity two to three feet down from the ridge



Option 2: Cut a hole into each truss cavity, big enough to inspect the opening and admit the fill tube



Pull cut edges of roof back to allow for inspection, repairs, and insulation installation



Option 3: Cut the roof open along the highest point from end to end. Make crosswise cuts at each end if needed



Regardless of access method, visually inspect attic for existing insulation, wiring, flues, obstructions, and hazards

4.1003.9e

Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

If the roof is sliced:

- A solid metal ridge cap will be centered over the slice
- A flexible and durable sealant will be sandwiched between the roof and the ridge cap
- Screws will be installed to prevent wrinkles and create a permanent seal
- Screws will not go into any wood framing
- A durable and flexible final coating will be applied over the screws and edge of the ridge cap to create a continuous seal between the roof and the perimeter of the ridge cap

For holes that are drilled or cut, the initial patch will be applied using the following procedure:

- At least 6" of surface surrounding the opening will be cleaned before patch is installed
- Sealant will be continuous and applied in between the patch and the roof
- Sealant will be an all-weather adhesive that is flexible and durable

If a metal patch is used:

- Patch will overlap the opening by 2" on all sides
- Gauge will be equal to or greater than the roof material
- Fasteners will be installed to prevent wrinkles and create a permanent seal
- If a plug is used, it will be flanged and have a tight fit
- Screws will not go into any wood framing

A durable and flexible 45 mil adhesive patch will be applied in accordance to manufacturer specifications over the initial patch and will have at a minimum:

- Tear strength of 640g
- Elongation of 380%
- Application temperature no lower than 55°F and no greater than 110°F
- Services temperature no less than -25°F and no greater than 150°F
- Adhesive patch will overlap the initial patch by 2" on all sides
- A durable and flexible final coating will be applied over the adhesive patch to create a continuous seal between the roof and the perimeter of the patch
- All remaining seams, edges, and penetrations will be sealed as necessary

Objective(s):

Effectively patch and seal all openings

Create a durable patch that will prevent roof leaks



In Progress

Rough cut hole that will need to be sealed.



In Progress

Placing sealant around the exposed edges of the roof patch ensures a watertight seal.

Tools:

1. Roller
2. Self adhering patch
3. sheet metal
4. 6" duct cap(to match 6" hole)
5. heat gun
6. drill

4.1003.9e - Patching and sealing openings



Insert 6" plug and seal around the perimeter of the opening.



Firmly push the plug into place, until it is flush with the roof surface.



Use a 10"x10" sheet metal patch to mark the center of the hole.



Apply sealant to the underside of the sheet metal patch.



Secure the metal patch to the roof being sure to place mechanical fasteners through the sealant.



Apply a 14"x14" self adhering roof patch on top of the sheet metal patch.



Use a heat gun to make the adhesive pliable to get the best possible seal.



Forcefully roll the patch into place, starting from the center and working toward the edge.

4.1003.9f

Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

Installation process will be considered complete when installer has verified that damage has not occurred to the roof or ceiling assemblies during the installation process

Objective(s):

Verify the integrity of the house has been maintained



In Progress

Verify that no damage has been done by the workers. When in doubt, verify with photo documentation.



After

Document and repair any damage the workers caused.

Tools:

1. IR camera

4.1003.10a

Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

All combustion appliance flues will be terminated to the exterior of the house and terminations will maintain proper clearance above snow loads

A distance no less than 2" will be maintained between any combustion appliance flue and combustible materials, unless zero clearance flue is in place

All ventilation systems will maintain a continuous connection and terminate to the outdoors

All broken mushroom vents will be replaced or removed and sealed

All plumbing stacks will be terminated to the outdoors

Non-IC rated light fixtures will be replaced with airtight IC-rated fixtures, if feasible and only when installed measures will compromise the fire rating of the fixture

All recessed lights will be labeled as having an air leakage rate no more than 2.0 CFM when tested in accordance with ASTM E 283 at a 75 pascals pressure differential

All obvious ceiling penetrations will be sealed

The space between combustion appliance flues and the ceiling will be sealed with fire-rated materials

All roof, attic, and ceiling assemblies will be structurally sound:

- Loose ceiling panels will be secured
- Temporary ceiling bracing will be recommended while installing installation

Dishing and pooling issues that allow standing water will be addressed

All known roof water leaks will be repaired before installing installation

Objective(s):

Ensure occupant and worker safety

Verify attic space is ready to insulate

Ensure structural integrity of the roof and ceiling assembly

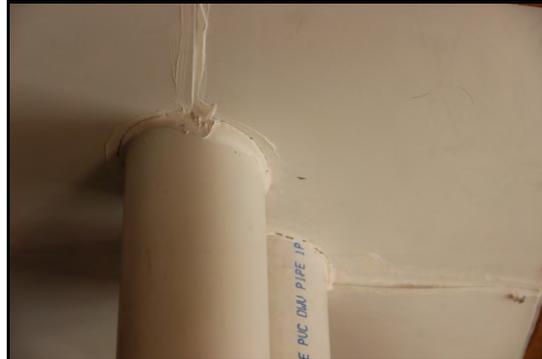
Prevent intrusion of bulk moisture

Prevent damage while installing insulation



Best Practice

90+ flue terminates above the snow line and penetrations have been sealed.



Best Practice

Flue penetrations have been sealed correctly from the interior.

4.1003.10a - Attic, ceiling, and roof verification



Plumbing stacks must be terminated to the outdoors.



Dishing and pooling issues must be addressed.



Mushroom vents must be replaced, or removed and sealed.



Proper clearance to combustibles will be maintained through the roof assembly.



Inspect ceiling for weakness, leaks, clearance to combustibles, loose panels, and penetrations.

4.1003.10b

Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

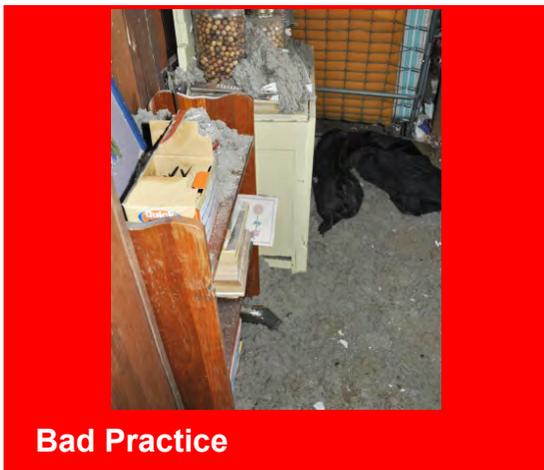
Specification(s):

Special precautions will be taken to limit fiberglass and construction dust exposure to the occupant and occupant belongings

Objective(s):

Protect occupant health and safety

Protect occupant belongings



Improperly prepared workspace with cellulose all over client belongings and bedroom



Worker has removed or covered occupant belongings. Be sure to ask permission before removing any client belongings

Tools:

1. Utility knife

Materials:

1. Plastic sheeting
2. Removable, low-residue tape

4.1003.10c

Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

Equidistant holes will be drilled in a straight row parallel to the longitudinal exterior wall of the ceiling

If a longitudinal ceiling trim piece exists, trim piece will be removed and holes will be drilled behind the trim

Hole location and size will be placed to provide access to allow for consistent and uniform coverage of installed insulation throughout the attic assembly

There will be, at a minimum, one hole between each roof truss

Holes will be large enough to accommodate the chosen fill tube without damaging the ceiling material during installation

If a vapor barrier or ceiling-mounted insulation is present, access will be gained through them

Attic will be visually inspected for the location of existing insulation, obstructions, hazards, and construction type

Objective(s):

Create access to the full attic cavity

Determine insulation installation technique

Prevent damage to ceiling

Create a professionally finished ceiling



In Progress

Holes are drilled in such a fashion that they allow uniform coverage of attic insulation.

Tools:

1. holesaw bit
2. drill
3. borescope
4. camera



In Progress

Hole is the proper size in relation to the fill tube.

Materials:

1. protective plastic

4.1003.10f

Desired Outcome:

Consistent, uniform thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

Holes will be plugged or covered and sealed to be aesthetically pleasing

If existing trim was removed, it will be reinstalled

Objective(s):

Create an airtight seal

Create a visually acceptable ceiling finish



In Progress

Holes should be effectively sealed, as well as aesthetically pleasing.

Tools:

1. color matched plug

Materials:

1. color matched plug

4.1104.1a

Desired Outcome:

Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

If skirting overlaps siding, skirting will be detached to allow access to the wall cavity

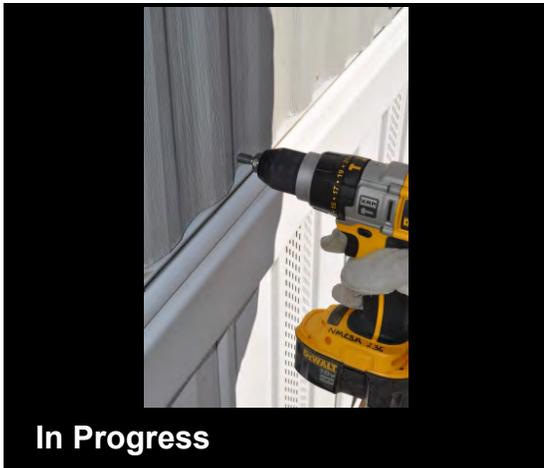
Fasteners will be removed from the bottom of the siding, working upward until the siding can be pulled away from the framing approximately 6" without damaging the siding

Temporary fasteners will be installed near the bottom of the siding panels at the seams to prevent separation

If a subsheathing is present under the siding, access through the subsheathing will be required

Objective(s):

Gain access to the wall cavity without damaging or separating the siding



In Progress

Remove fasteners from along bottom and side seams to access wall cavity



After

Remove enough fasteners to create at least a 6in gap without damaging siding

Tools:

1. Drill

4.1104.1a - Access wall cavities



1
If skirting overlaps siding, remove skirting



2
Temporarily fasten siding panels at joint to hold seam together



3
Seam should remain together with temporary fastener

4.1104.1b

Desired Outcome:

Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

Wall cavities will be inspected for moisture damage, pest locations, and integrity of the wiring, and holes to the interior

Siding will be repaired as necessary

Location of belt rails, obstructions, and existing insulation will be identified

All interior surfaces of exterior walls will be inspected for loose paneling joints, occupant wall hangings, location of switches and outlets, and other wall obstructions

Objects will be removed from the interior surfaces of the walls being insulated

Interior paneling will be repaired as necessary

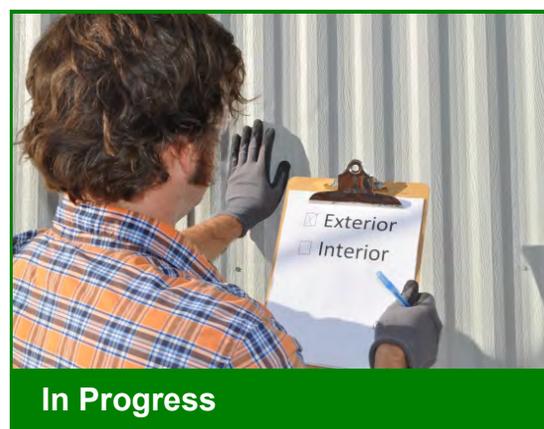
Objective(s):

Prepare wall cavity for insulation

Prevent water leaks from occurring



Take note of obstacles in the wall cavity, such as belt rails and electrical wiring



Assess that holes in both exterior siding and interior walls have been patched before beginning installation

Tools:

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

Materials:

1. Spackle
2. Metal siding patch
3. Caulk
4. Fasteners

4.1104.1b - Exterior wall cavity inspection



Obstacles should be noted and planned for--insulation should be tucked behind belt rails



2 Holes in exterior siding should be patched



3 Apply sealant to back of patch to maintain air barrier



4 Ensure that patch is securely fastened and water-tight



5 Holes and penetrations in the interior wall should be patched as well



6 Verify that patches to both interior and exterior have been completed before beginning installation

4.1104.1c

Desired Outcome:

Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

A sheet of polycarbonate, such as Lexan, will be cut to the following specifications to create a stuffer tool:

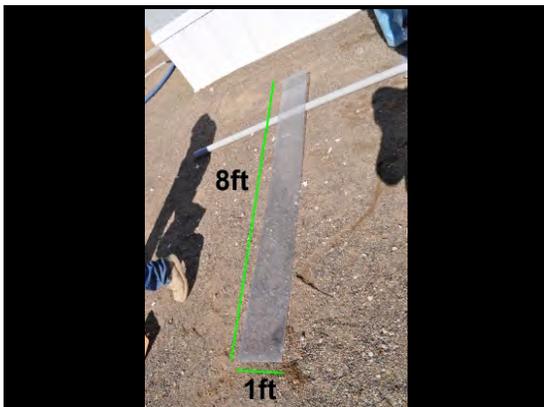
- Approximately 1' x 8' x 1/4" with a 5 degree bend 7' 1/2" from the bottom
- All corners of the Lexan (polycarbonate) will be rounded and all edges will be sanded

Other clear sheet plastics will not be used due to a tendency to shatter under stress

Objective(s):

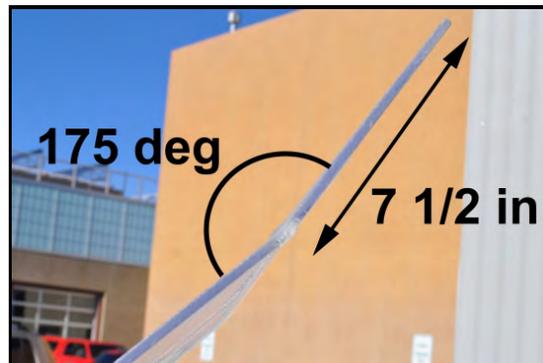
Create a tool to install a fiberglass batt into the cavity

Ensure worker safety



Best Practice

Insulation stuffing tool should be made of 1/4" polycarbonate, cut to 1' wide and 8' long



Best Practice

At one end, a bend of 5 degrees (175 degree supplement) should be made 7 1/2" from narrow edge

Tools:

1. Tape measure
2. Table saw with fine-toothed blade
3. Sander
4. Heat gun
5. Clamp
6. Protractor
7. Heat-resistant gloves

Materials:

1. Polycarbonate, like Lexan
2. Sandpaper

Most crews should have this tool in their supply. If one needs to be fabricated, find someone who has worked with polycarbonate before and ensure correct tool usage as well as proper PPE during fabrication.

4.1104.1d

Desired Outcome:

Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

Thickness of the batt will fill the void without deforming siding or damaging structure

Fiberglass batts will fill the cavity (e.g., batt may be cut approximately 1" longer to ensure proper fill and allow for lap at the top)

Flexible membrane will have an appropriate perm rating for the region

Flexible membrane will be cut 2" wider than the cavity and approximately 1' longer than the batt

Stuffer tool, membrane, and fiberglass batt will be aligned for installation

Stuffer tool will be used to install the fiberglass batt and membrane at the same time

Excess fiberglass batt and membrane vapor retarder extending below the cavity will be rolled and tucked into the cavity

A poly-encased fiberglass batt may be used in place of the fiberglass batt and membrane assembly

The membrane will be installed in contact with the side of the wall that is compatible with the local climate zone

Objective(s):

Maintain integrity of the batt

Aid in the installation process



Before

Uninsulated and underinsulated wall cavities can be filled from the exterior with fiberglass batts

Tools:

1. Tape measure
2. Utility knife



After

Fiberglass batt should fill entire cavity without creating bulging in exterior paneling

Materials:

1. Fiberglass batts, may be wrapped
2. Vapor barrier appropriate for region

4.1104.1d - Fiberglass batt installation



1
Uninsulated wall cavity can be accessed from exterior of mobile home through paneling



2
Measure length of cavity



3
Measure depth of cavity



4
Select appropriate batt thickness and R-value. Wrapped batts provide a built in vapor barrier



5
Measure batt to length of cavity with extra for overlap from stuffing tool



6
Lap cut batt over bent end of stuffing tool



7
Beginning with lapped end, tuck batt under top belt rail and stuff batt up to top of cavity. Remove stuffing tool



8
Tuck bottom of batt behind bottom belt rail. If longer than cavity, cut to within 1" longer, roll and tuck into cavity

4.1104.1f

Desired Outcome:

Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):

If skirting was removed, skirting will be reinstalled to shed water to the outside of the skirting

Siding will be reattached with new fasteners

Siding will be reattached without bulges or wrinkles

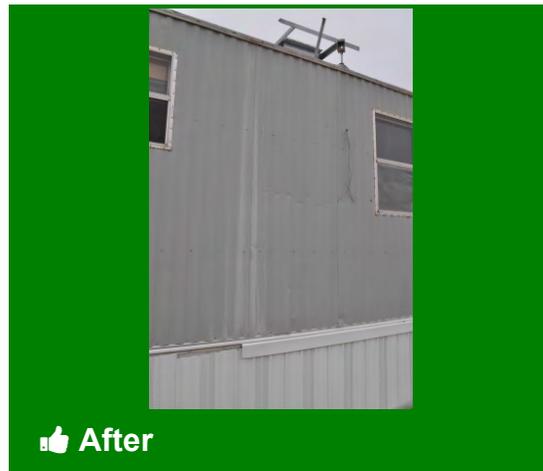
Objective(s):

Ensure the integrity of the drainage plane

Return siding to existing conditions without damage



After wall cavities have been stuffed, paneling needs to be put back into place and refastened



Once work is finished, reattach siding and skirting, ensuring neither have been damaged

Tools:

1. Drill

Materials:

1. Fasteners

4.1104.1f - Reattachment



1
Using new fasteners, reattach paneling



2
Reinstall skirting, if necessary



3
Reattach trim, if necessary



4
Verify that siding and skirting have not been damaged and show no signs of bulging

4.1303.1a

Desired Outcome:

Consistent thermal boundary between conditioned and unconditioned space that reduces heat flow

Specification(s):

Insulation will be installed in accordance with recommended R-value and density

Objective(s):

Insulate to prescribed R-value for the climate zone

Zone	Floor
1	R13
2	R13-R19
3	R19-R25
4 to 8	R25-R30

R-value should be determined by climate zone, and be listed in work order

Area de recubrimiento para aplicaciones de
Peso neto por

Thermal Resistance R-value Resistencia al flujo calórico Valor R	Cavity Depth/ Installed Thickness inches Espesor instalado/ Espacio de la cavidad Pulgadas	Minimum Installed Density lbs/ft ³ Densidad mínima instalada libras/p ³
13	3.5	1.0
20	5.5	
14	3.5	1.4
22	5.5	
15	3.5	1.8
23	5.5	

* BIBS = Blow-In Blanket® System; Sistema de Manto de Fibra de Vidrio al Soplo

Best Practice

Consult density chart on insulation packaging to determine proper insulation application to achieve prescribed R-value

4.1303.1e

Desired Outcome:

Consistent thermal boundary between conditioned and unconditioned space that reduces 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 minimum 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

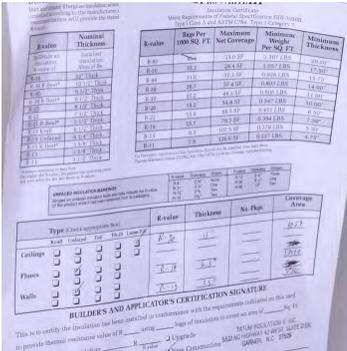
Comply with 16 CFR 460.17



Best Practice

Provide occupant with signed, dated receipt documenting information about insulation installed

4.1303.1e - Occupant education



Documentation should include insulation material and r-value



Provide occupant with copies of all documentation



Communicate professionally with occupant to provide information and support

4.1303.2b

Desired Outcome:

Consistent thermal boundary between conditioned and unconditioned space that reduces heat flow

Specification(s):

Ensure complete accessibility of floor cavity

Clean floor cavities

Remove all remnants of previous insulation and bottom board

Objective(s):

Ensure work area is clean, safe, and ready to accept insulation



 Before

Cavity spaces that are to be insulated need to be cleared of old insulation and debris



 After

Once cavity is cleared, it is ready for new insulation

Tools:

1. Utility knife

4.1303.2b - Work assessment



Remove old rodent barrier and insulation



Cavities should be completely cleared of debris

4.1303.2c

Desired Outcome:

Consistent thermal boundary between conditioned and unconditioned space that reduces heat flow

Specification(s):

Each cavity will be insulated to specified R-value and density

If insulation has facing, facing will be in contact with the heated side

Insulation will be in contact with subfloor

Insulation will not have gaps, voids, or be compressed

Insulation will be supported (e.g., metal insulation supports) to maintain a permanent contact with subfloor

Insulation will be notched around all wires, pipes, and blocks

Ducts and water lines will be insulated for climate conditions

Water lines will be located above the warm side of the insulation (toward the conditioned space), when feasible

A rigid air barrier will be installed in contact with the bottom of the joists, when feasible

Rigid air barrier will be fastened as to not sag, bend, or fall off

Seams, holes, and joints in the air barrier will be sealed

In cases where HVAC ducts hang below the level of the rigid air barrier and insulation, the ducts will be insulated and air barrier provided that is sealed to the rigid air barrier

Objective(s):

Eliminate voids

Minimize conductive heat transfer across the floor system

Ensure durability

Minimize convective heat transfer

Keep pipes from freezing



Uninsulated floors over unconditioned spaces are an energy drain



In addition to fiberglass batt insulation, a rigid air barrier will be sealed and mechanically fastened in place

Tools:

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

Materials:

1. Fiberglass batts, may be kraft-faced
2. Metal tape
3. Insulation supports (lightning rods)
4. Fasteners
5. Caulk
6. Duct insulation

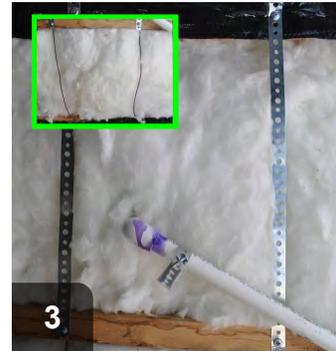
4.1303.2c - Insulate floors



1 If fiberglass insulation is kraft-faced, ensure kraft is in contact with subfloor



2 Notch insulation around pipes, blocks, and other obstructions



3 To prevent insulation from moving away from subfloor, supports should be fastened in place



4 A rigid air barrier should be securely in place so prevent sagging, gaps and penetrations should be sealed



5 When ductwork or water pipes run below joists, insulation should be threaded above to fill joist cavity, uncompressed



6 Water lines and ducts should be insulated if running below joists



7 A rigid air barrier should be mechanically fastened to hold it tight against the floor joists



8 When insulating around low-hanging ducts and water pipes, run a line of sealant before placing insulation



9 Insulation around ducting should be securely fastened and sealed to maintain air barrier

4.1303.2d

Desired Outcome:

Consistent thermal boundary between conditioned and unconditioned space that reduces heat flow

Specification(s):

Insulation materials will be of minimal water absorbency and flame spread, and smoke-developed index for insulation will be in accordance with current industry acceptable standards

Foam plastic insulation will comply with industry acceptable standards

Fasteners will be corrosion resistant

Objective(s):

Ensure durability

Prevent moisture damage



Bad Practice

Do not use absorbent insulation material, such as cellulose, in the floor cavity



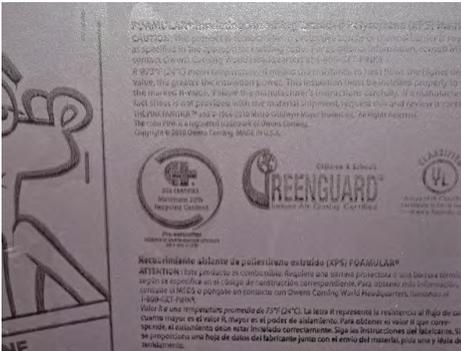
Best Practice

Fiberglass batts are a good choice for insulating floor cavities

Materials:

1. XPS insulation board
2. Fiberglass batts
3. Corrosion resistant exterior screws

4.1303.2d - Materials



XPS insulation board is a non-absorbent insulation option



XPS (extruded polystyrene) is safe for use in floor cavities



Do not use EPS (expanded polystyrene) foam board in floor cavities due to flame spread rate



Use only corrosion resistant, exterior screws as fasteners in floor cavities

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



 Before

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



 After

Insulation and drywall create an air barrier

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

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

Desired Outcome:

Basement insulation improves thermal performance and ensures sufficient drying potential

Specification(s):

When absorbent insulation materials are installed, assembly will remain vapor permeable to the interior in all climate zones except Zone 7 (<http://energycode.pnl.gov/EnergyCodeReqs/>)

Objective(s):

Provide drying potential to the basement



Kraft-faced fiberglass insulation is absorbent



Drywall typically has a perm rating of 50--good for zones 1-6

Tools:

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

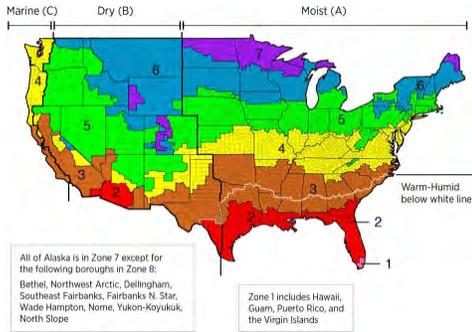
Materials:

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

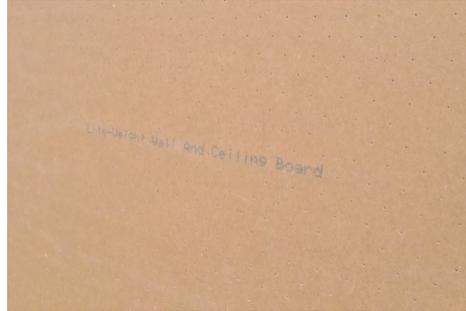
The higher a material's perm rating, the more vapor can pass through said material. Drywall typically has a perm rating of approximately 50.

In zones 7 & 8 (AK, parts of MN, ND, WI, MI, WY, CO, and ME), vapor retarders should be used to minimize freezing. For vapor retarders in basements and crawl spaces, Vapor retarders must be 6 mil or better.

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

4.1601.4b

Desired Outcome:

Lower conductive heat transfer by ducts and decrease condensation on duct vapor barrier

Specification(s):

All flexible ducting will have a minimum of R-8

Objective(s):

Minimize thermal conductance through the duct system



👎 Before

Existing flex duct that does not meet the requirement of R-8.0 should be removed



👍 After

All replacement ducting should be R-8.0, minimum

Tools:

1. Tie band tensioner

Materials:

1. Flex duct, min R-8

4.1601.4c

Desired Outcome:

Lower conductive heat transfer by ducts and decrease condensation on duct vapor barrier

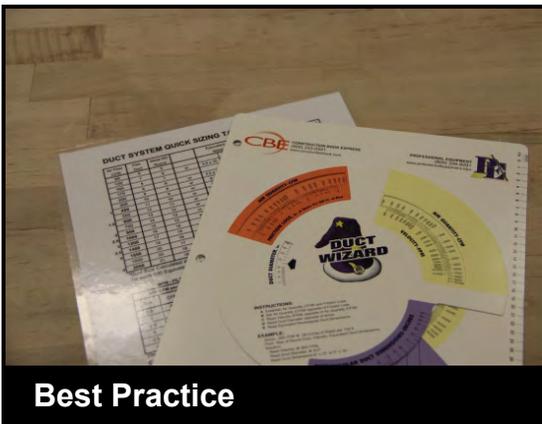
Specification(s):

Duct-sizing procedures will be conducted when replacing flex duct

Objective(s):

Improve comfort in rooms

Improve fan performance



Best Practice

Ducts should be sized according to how much airflow is needed for a room.

Tools:

1. Duct-u-lator or ACCA equivalent

4.1601.4d

Desired Outcome:

Lower conductive heat transfer by ducts and decrease condensation on duct vapor barrier

Specification(s):

Flex duct will be supported in accordance with flex duct manufacturer's directions or local codes

Beaded rigid elbow or equivalent will be installed in duct runs whenever change in direction is required

Objective(s):

Prevent sags, drops, or other bends that may interfere with correct air flow

Maintain duct diameter around the turns

Maximize air flow and distribution



Straps should be at least 1.5" wide.



Straps should be placed in accordance with manufacturers specification, typically 4ft.

Materials:

1. 1.5" webbing or strap material

4.1601.4d - Installation of flex



Elbows are required when a change in direction is needed.

4.1601.4e

Desired Outcome:

Lower conductive heat transfer by ducts and decrease condensation on duct vapor barrier

Specification(s):

Interior liner of the flex-to-metal connection will be fastened with tie bands using a tie band tensioning tool

For oval flexible duct-to-metal connections, tie bands cannot be used; appropriate mechanical fasteners will be used

Objective(s):

Create a strong, secure attachment



Before

Duct liner has been sealed, but tie band has not been installed.



After

Liner has been securely fastened with tie band tensioning tool.

Tools:

1. tie band tensioning tool

Materials:

1. tie band

4.1601.4f

Desired Outcome:

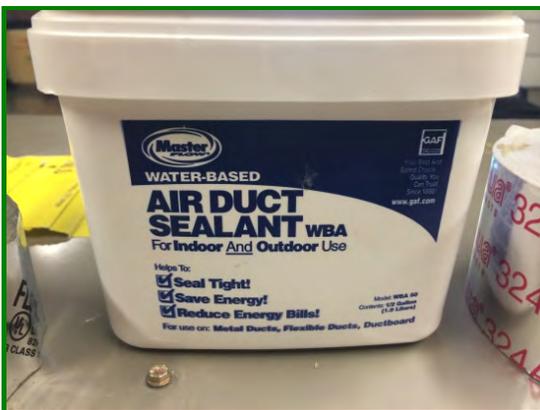
Lower conductive heat transfer by ducts and decrease condensation on duct vapor barrier

Specification(s):

UL 181 B-M-listed mastic product will be used to seal the connection

Objective(s):

Create an airtight connection



Best Practice

Using a product like the mastic shown here results in an airtight connection

Materials:

1. UL 181 B-M listed mastic product

4.1601.4g

Desired Outcome:

Lower conductive heat transfer by ducts and decrease condensation on duct vapor barrier

Specification(s):

Liner will be pulled up onto the metal duct as far as possible before securing

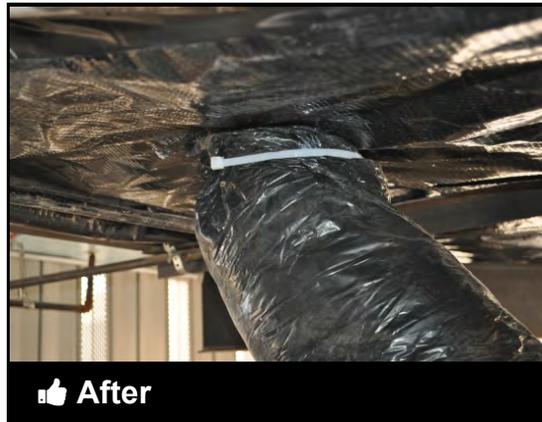
The exterior liner of the flex duct will be fastened with tie bands using a tie band tensioning tool

Objective(s):

Create a strong, durable attachment



Pull the outer liner so that all exposed surfaces are covered.



Duct is properly secured with a trimmed tie band.

Tools:

1. tie band tensioning tool

Materials:

1. tie band

4.1601.4g - Attachment of exterior liner



1
Outer liner should be pulled up to cover all un-insulated surfaces.



2
Secure the tie band in place by hand or using a tie band tension tool.



3
Trim the excess tie band material.

4.1601.4h

Desired Outcome:

Lower conductive heat transfer by ducts and decrease condensation on duct vapor barrier

Specification(s):

All accessible joints, seams, and connections will be sealed with UL 181 approved mastics

Objective(s):

Minimize duct leakage



In Progress

Here the technician is inspecting work in progress, ensuring a good seal.



After

The duct boot has been properly sealed, even though the area is difficult to reach.

Tools:

1. inspection mirror

Materials:

1. mastic
2. duct boot

4.1601.4i

Desired Outcome:

Lower conductive heat transfer by ducts and decrease condensation on duct vapor barrier

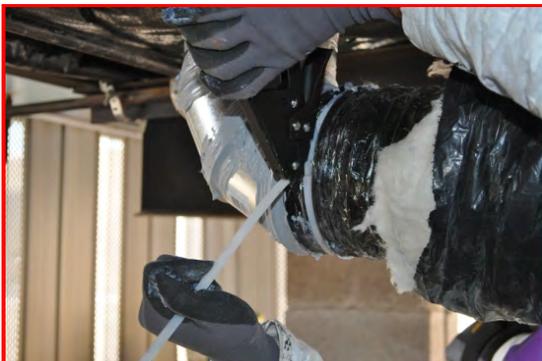
Specification(s):

All metal fittings, including boots, elbows, and takeoffs, will be insulated separately using a minimum of R-8 duct wrap with a vapor barrier mechanically fastened (e.g., stitch staples, tie bands) and sealed with no exposed metal

Objective(s):

Minimize thermal conductance of the duct system

Minimize condensation



 Before

This elbow has been sealed, but is not insulated.



 After

Fitting has been sealed and properly insulated.

4.1601.4j

Desired Outcome:

Lower conductive heat transfer by ducts and decrease condensation on duct vapor barrier

Specification(s):

Vapor barrier of all duct insulation will be taped to the flex duct using the taping system required by the manufacturer of the duct insulation

Vapor barrier will be sealed to the belly liner

Objective(s):

Ensure a complete vapor barrier



Crossover duct with vapor barrier mended and sealed to manufactured home belly

Tools:

1. Reusable spray foam gun
2. Utility knife
3. Scissors
4. Outward clinching (stitch) stapler

Materials:

1. UL-181 B-M foil or Mylar tape
2. Foam sealant
3. Staples

Clean vapor barrier thoroughly before applying UL 181B Mylar tape to cuts and seams. Repair belly if necessary, and use foam sealant to seal the vapor barrier to the belly.

4.1601.4k

Desired Outcome:

Lower conductive heat transfer by ducts and decrease condensation on duct vapor barrier

Specification(s):

Vermin access points will be identified and treated appropriately (e.g., seal access holes)

Objective(s):

Ensure long-term durability of the building materials



 Before

Flexible ducts are susceptible to vermin entry.



 After

Flex that has been damaged by vermin entry must be replaced or repaired.

4.1601.5a

Desired Outcome:

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

Specification(s):

Duct insulation will be a minimum of R-8, in accordance with local code or buried under attic insulation, whichever is a greater R-value, and have an attached and continuous vapor barrier

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

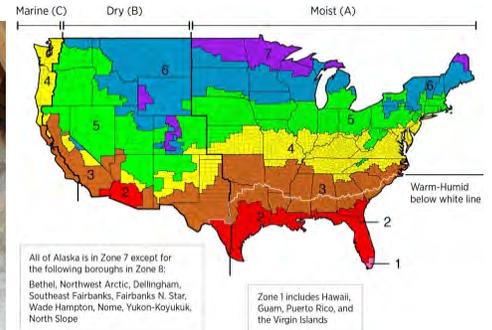
4.1601.5a - Selection of duct insulation material



Ducts in unconditioned areas should have r-8 insulation with vapor barrier



OR ducts can be buried in loose fill in attic spaces in drier climates



Burying ducts is discouraged in warm coastal and hot humid regions

4.1601.5c

Desired Outcome:

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

Specification(s):

Duct insulation will be mechanically fastened (e.g., stitch staples, tie bands) and sealed with no exposed metal

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

Mechanical fastening will be sufficient to securely hold the duct insulation in place and tight to the duct

Objective(s):

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

Ensure performance of the installed material

Minimize condensation



Materials holding insulation in place should not compress or kink duct



Durable materials can be attached without compressing insulation

Tools:

1. Scissors
2. Metal snips

Materials:

1. Nylon twine
2. Wire
3. Tie bands

4.1601.5d

Desired Outcome:

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

Specification(s):

Using a tape approved by the manufacturer, all seams and connection of the vapor barrier will be taped so that no metal is exposed

No gaps will exist between pieces of duct insulation

Objective(s):

Prevent gaps in the vapor barrier of the insulation



 Before

Unsecured and sealed insulation around ducts is useless



 After

All seams should be sealed with UL-181 duct tape to preserve vapor barrier

Tools:

1. Utility knife

Materials:

1. UL-181 tape
2. R-8 duct insulation with vapor barrier

5.3003.1a

Desired Outcome:

Data for commissioning and future service work is recorded

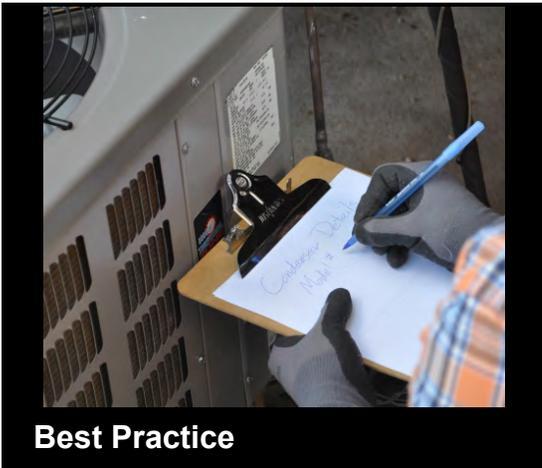
Specification(s):

Equipment will be visually inspected

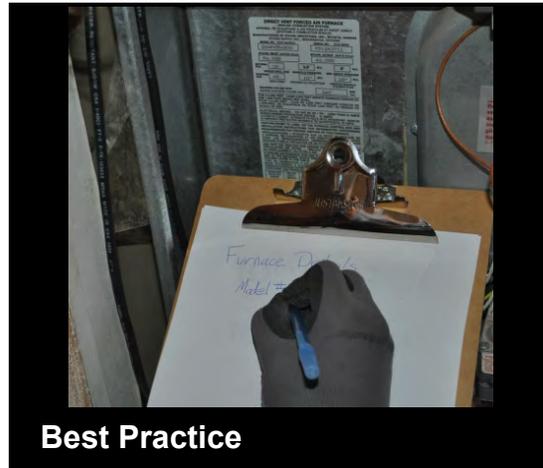
Information will be recorded from the equipment data plates indoors and outdoors

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

5.3003.2a

Desired Outcome:

Analysis of critical components and operations completed to industry and manufacturer specifications

Specification(s):

Smoke test will be conducted before any combustion testing is completed

Smoke spot reading will be in accordance with burner manufacturer specifications

Objective(s):

Ensure equipment:

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



Best Practice

Verify oil-fired furnaces and water heaters are operating safely



Best Practice

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

Tools:

1. Smoke testing pump

Materials:

1. Filter paper

5.3003.2a - Oil system: smoke test



1 Place filter paper in testing pump and draw air through paper



2 Remove paper and verify draw was successful by checking for soot



3 Compare level of soot deposit against smoke chart. A rating of 0 is ideal



4 Appliances with ratings of 3 or higher should be cleaned and tuned

5.3003.2b

Desired Outcome:

Analysis of critical components and operations completed to industry and manufacturer specifications

Specification(s):

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

Objective(s):

Ensure equipment:

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



Best Practice

Locate nozzles on oil-fired water heaters and furnaces

Nozzle Rating at 100 PSI	Nozzle Flow Rates In Gallons Per Hour (Approx.)					
	120 PSI	140 PSI	160 PSI	175 PSI	200 PSI	300 PSI
0.40	0.44	0.47	0.51	0.53	0.57	0.69
0.50	0.55	0.59	0.63	0.66	0.71	0.87
0.60	0.66	0.71	0.76	0.79	0.85	1.04
0.65	0.71	0.77	0.82	0.86	0.92	1.13
0.75	0.82	0.89	0.95	0.99	1.06	1.30
0.85	0.93	1.01	1.08	1.12	1.20	1.47
0.90	0.99	1.10	1.14	1.19	1.27	1.56
1.00	1.10	1.20	1.26	1.32	1.41	1.73
1.10	1.20	1.31	1.39	1.46	1.56	1.91
1.20	1.31	1.42	1.52	1.59	1.70	2.08
1.30	1.48	1.60	1.71	1.79	1.91	2.34
1.50	1.64	1.77	1.90	1.98	2.12	2.60
1.65	1.81	1.95	2.09	2.18	2.33	2.86
1.75	1.92	2.07	2.21	2.32	2.47	3.03
2.00	2.19	2.37	2.53	2.65	2.83	3.46
2.25	2.46	2.66	2.85	2.98	3.18	3.90
2.50	2.74	2.96	3.16	3.31	3.54	4.33
2.75	3.01	3.25	3.48	3.64	3.89	4.76
3.00	3.29	3.55	3.79	3.97	4.24	5.20

After

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

Tools:

1. Calipers

5.3003.2c

Desired Outcome:

Analysis of critical components and operations completed to industry and manufacturer specifications

Specification(s):

Filter will be present, clean, and leak free

Objective(s):

Ensure equipment:

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



Best Practice

Filter is present, clean, and shows no signs of leakage

5.3003.2e

Desired Outcome:

Analysis of critical components and operations completed to industry and manufacturer specifications

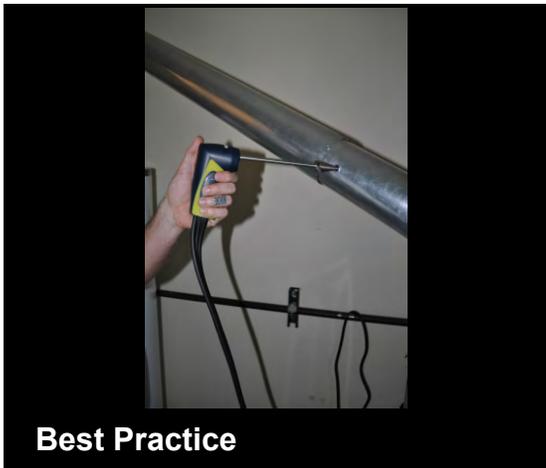
Specification(s):

Measurement will be verified in accordance with manufacturer specifications

Objective(s):

Ensure equipment:

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



Best Practice

Test flue gases to determine steady state efficiency



Best Practice

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

Tools:

1. Combustion analyzer with probe

5.3003.2f

Desired Outcome:

Analysis of critical components and operations completed to industry and manufacturer specifications

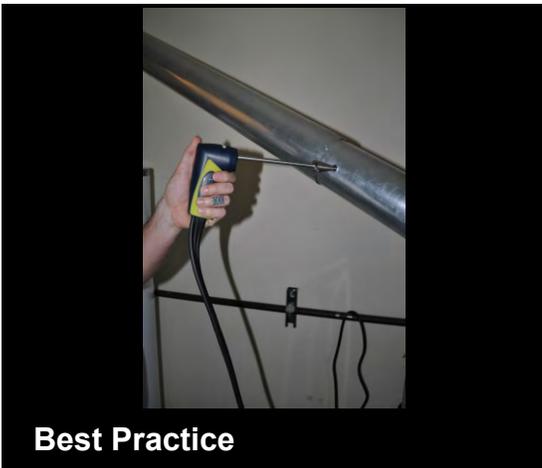
Specification(s):

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

Objective(s):

Ensure equipment:

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



Best Practice

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



After

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

Tools:

1. Combustion analyzer with probe

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

5.3003.2g

Desired Outcome:

Analysis of critical components and operations completed to industry and manufacturer specifications

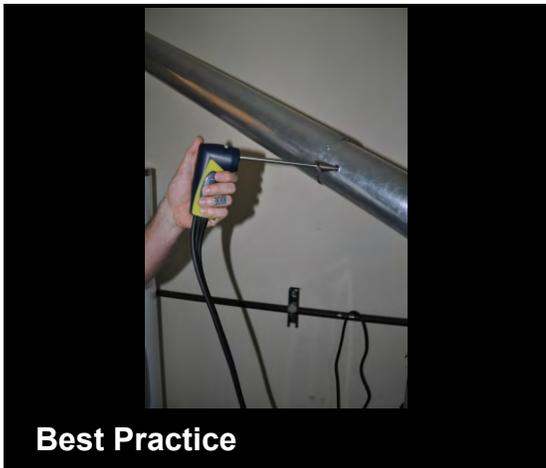
Specification(s):

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

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



After

Levels should be within industry standards and match manufacturer specs

Tools:

1. Combustion analyzer with probe
2. Drill

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 of critical components and operations completed to industry and manufacturer specifications

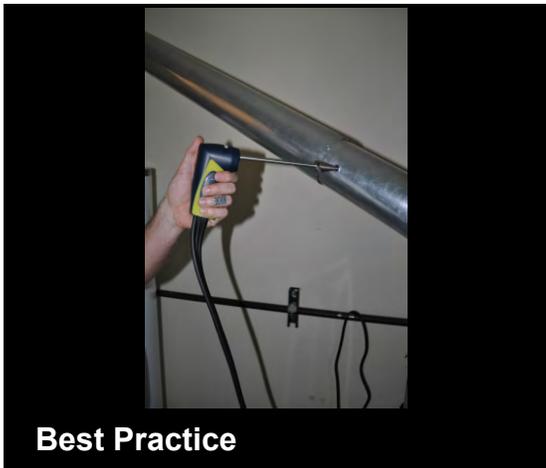
Specification(s):

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

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



After

CO should measure less than 100ppm

Tools:

1. Combustion analyzer with probe
2. Drill

5.3003.3h

Desired Outcome:

Air flow is properly tested

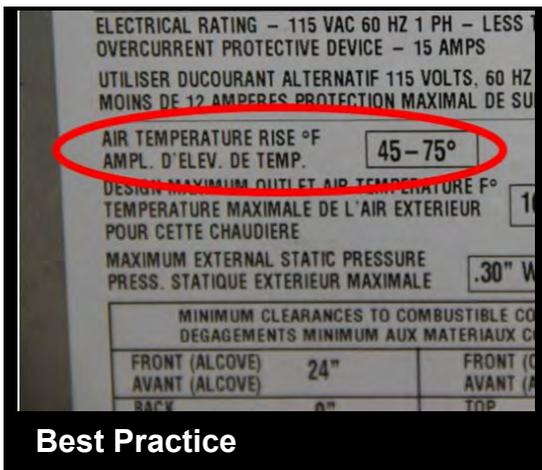
Specification(s):

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.

5.3003.11a

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

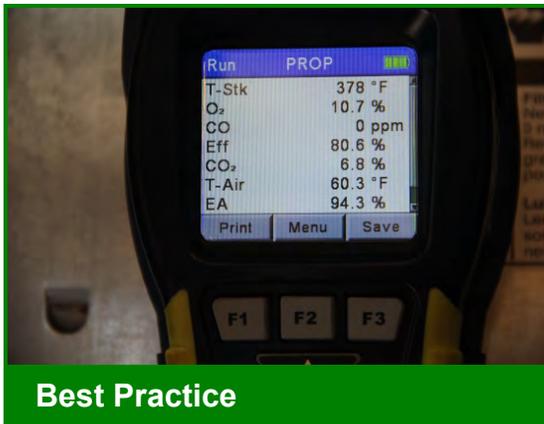
Specification(s):

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

6.6002.4b

Desired Outcome:

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

Specification(s):

Ducts installed outside of the thermal envelope will be insulated to a minimum of R-8 or in accordance with local codes

Objective(s):

Prevent condensation from forming or collecting inside or outside of the ductwork



👎 Before

Existing flex duct that does not meet the requirement of R-8.0 should be removed



👍 After

All new and replacement ducting in unconditioned spaces should be R-8.0 minimum

6.6002.4c

Desired Outcome:

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

Specification(s):

Horizontal runs will be supported in accordance with flex duct manufacturer specifications and local codes

Supports with a width of at least 1 ½" will be used or adequate metal support

Objective(s):

Effectively move the required volume of air

Preserve the integrity of the duct system



Straps should be at least 1.5" wide.



Straps should be spaced in accordance with manufacturers specification, typically 4ft.

Materials:

1. 1.5" webbing or strap material

6.6002.4d

Desired Outcome:

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

Specification(s):

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

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

PVC-to-PVC connections 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



For flex to metal connections, use zip tie and tensioner to secure liner to connection fitting.

Tools:

1. drill
2. tie band tensioner

Materials:

1. mechanical fastener
2. tie bands
3. PVC primer and cement

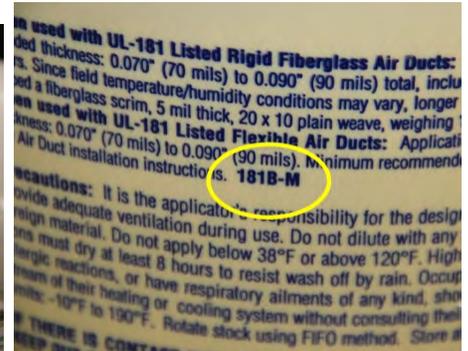
6.6002.4d - Duct connections



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.

6.6002.4e

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, smooth metal of 30-gauge wall thickness or thicker will be used

PVC material may be used

Objective(s):

Effectively move the required volume of air

Preserve the integrity of the duct system



This material conforms to UL Standard 181.

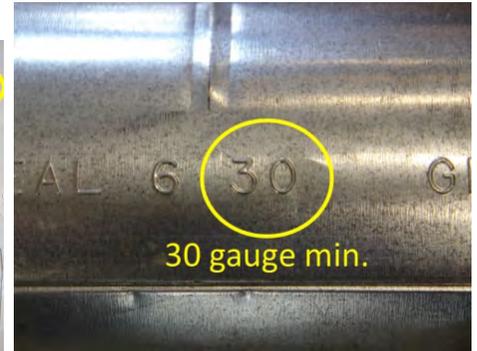
6.6002.4e - Duct materials



Look for the Air Diffusion Council seal.



Flex installed should meet or exceed UL181.



When rigid duct is being used, its wall thickness should be 30 gauge minimum.

6.6002.4f

Desired Outcome:

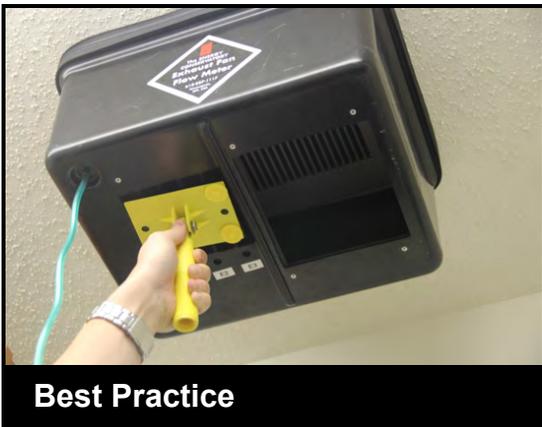
Installed ducts effectively move the required volume of air and prevent condensation

Specification(s):

Total exhaust system ventilation airflow will be measured

Objective(s):

Ensure air flow is as designed



Exhaust fan flow should be measured and compared with the fans rated capacity as well as ASHRAE 62.2 requirements.

Tools:

1. Exhaust fan flow meter
2. Manometer

ASHRAE requires the following flows for bath fans: 50CFM intermittent, or 20CFM continuous.

The requirements for kitchen range hoods are: 100CFM intermittent, or 5ACH(for kitchen area) continuous.

6.6003.1a

Desired Outcome:

Surface-mounted ducted fans installed to specification

Specification(s):

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

Objective(s):

Minimize repair work

Ensure a secure installation



In Progress

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
3. Writing utensil

6.6003.1a - Hole through interior surface



Measure the termination fitting to determine proper hole diameter (in this case, 4")



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



Clear wall surface and mark hole size 1/4" larger than termination fitting



Since opening is larger than most hole saws, precision cutting is important

6.6003.1b

Desired Outcome:

Surface-mounted ducted fans installed to specification

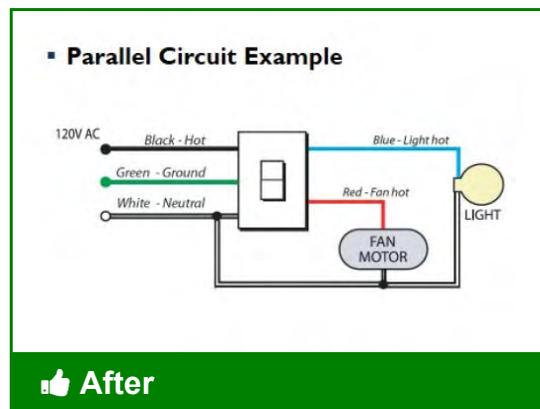
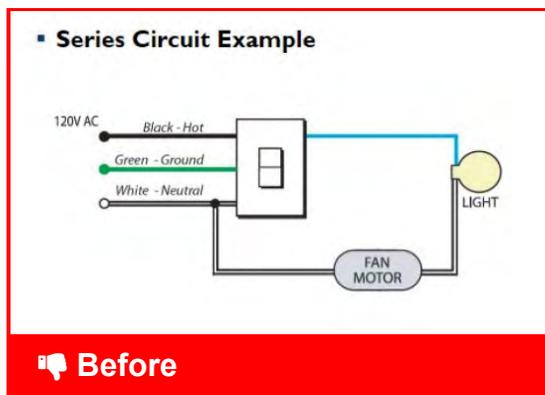
Specification(s):

Wiring will be installed by a properly licensed contractor, as required by the authority having jurisdiction

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



6.6003.1c

Desired Outcome:

Surface-mounted ducted 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 in accordance with manufacturer specifications

Objective(s):

Ensure short duct run to achieve optimum air flow

Ensure a secure installation

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



Bad Practice



Best Practice

6.6003.1d

Desired Outcome:

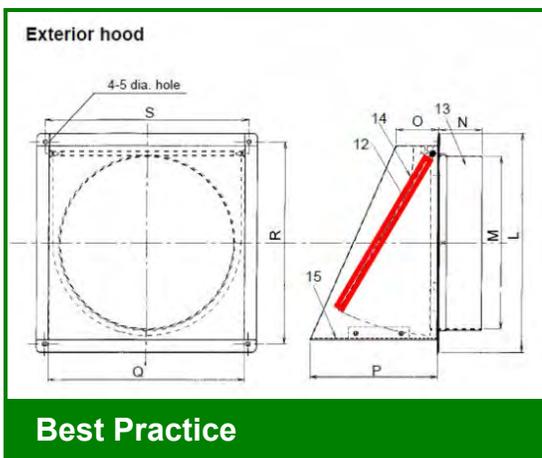
Surface-mounted ducted fans installed to specification

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

6.6003.1f

Desired Outcome:

Surface-mounted ducted fans installed to specification

Specification(s):

Gaps and holes in fan housing will be sealed with caulk or other sealants in accordance with manufacturer recommendations

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

Prevent a fire hazard

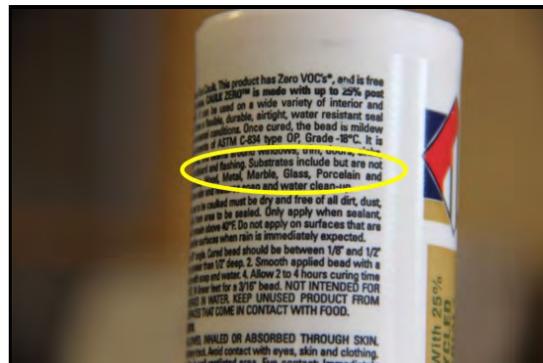


Best Practice

Seal openings in the fan housing to ensure that air is exhausted only from the desired location.

Tools:

1. caulk gun



Best Practice

Sealant should be approved for its intended surfaces.

Materials:

1. caulk

6.6003.1g

Desired Outcome:

Surface-mounted ducted 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 between house and fan



The opening for the fan is unsealed, allowing air leakage into or out of the attic.



The fan to interior surface seal is made using the proper materials and prevents airflow to and from the attic space.

6.6003.1i

Desired Outcome:

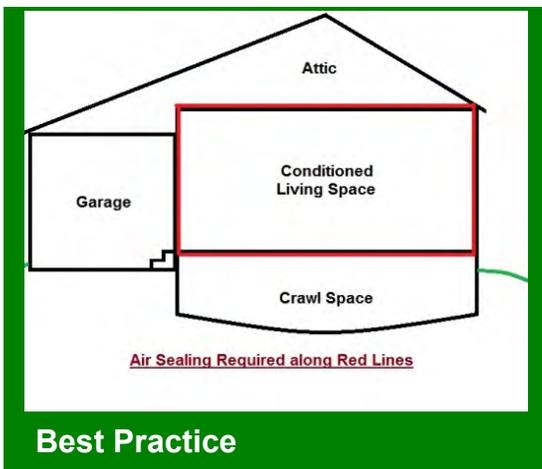
Surface-mounted ducted fans installed to specification

Specification(s):

Leakage to the house from other spaces will be prevented (e.g., garages, unconditioned crawl spaces, unconditioned attics)

Objective(s):

Ensure occupant health and safety



The barrier between conditioned and unconditioned spaces should be sealed

6.6003.5b

Desired Outcome:

Contaminants properly removed from house

Specification(s):

Air leakage between the house and garages will be prevented by sealing and weatherstripping

Objective(s):

Ensure occupant health and safety

Reduce conditioned air being drawn from the house

Reduce contaminant migration from garage to house



Before

The reading is zero indicating strong connection with the garage.



After

The reading is closer to 50, indicating the garage is connected to the outside.

Tools:

1. blower door assembly
2. manometer

6.6003.5b - Air leakage



Depressurize the house to 50 pascals.



The reading of 50 pascals indicates the zone is more closely connected to the outside.

6.6003.6f

Desired Outcome:

Provide primary ventilation for common spaces

Specification(s):

Total exhaust system airflow will be measured

Objective(s):

Ensure exhaust airflow is as designed



Measure the fan flow with the flow meter.

Tools:

1. Exhaust fan flow meter
2. Manometer

ASHRAE requires the following flows for bath fans: 50CFM intermittent, or 20CFM continuous.

The requirements for kitchen range hoods are: 100CFM intermittent, or 5ACH(for kitchen area) continuous.

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 wrong material



 **After**

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

Tools:

1. Metal snips
2. Drill

Materials:

1. Metal flex duct
2. Dryer vent kit
3. Hose clamps

6.6005.1a - Clothes dryer ducting



Disconnect existing vent pipe from termination. If hose clamp is installed, save for reuse.



Disconnect existing vent pipe from dryer.



Attach approved vent material to termination vent. Termination vent may need to be trimmed.



Trim metal vent to ensure the run is as short and straight as possible.



Connect vent pipe to dryer.



Dryer vents to outdoors, and exhaust damper is functional.



For vent runs >35 feet, a booster fan is required.



Duct runs outside of conditioned space must be insulated and properly supported.

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

6.6005.1c

Desired Outcome:

Dryer air exhausted efficiently and safely

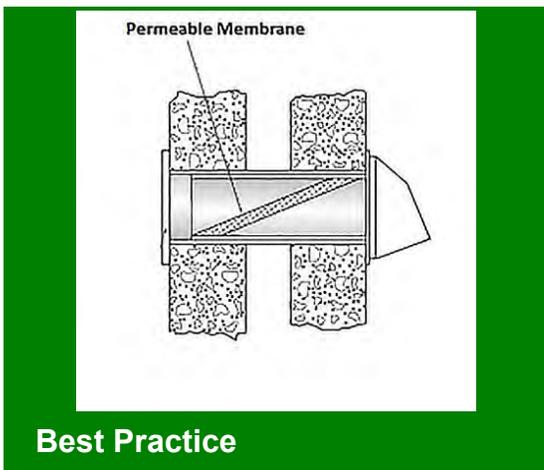
Specification(s):

Makeup air will be provided for appliances exhausting more than 200 CFM

Objective(s):

Preserve integrity of building envelope

Effectively move air from clothes dryer to outside



Best Practice
A passive inlet vent can provide make-up air for dryer exhaust

Tools:

1. Drill
2. Hole saw
3. Caulk gun

Materials:

1. Caulk sealant
2. Fasteners

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



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



Test to verify combustion appliances are within depressurization limits

Tools:

1. Manometer

See SWS 2.0299.1a-i for CAZ depressurization limits

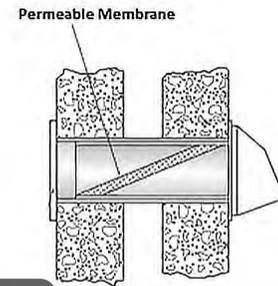
6.6005.1d - Combustion safety



Run depressurization testing on house to ensure new ventilation isn't causing unsafe conditions



If depressurization limit is exceeded, mitigate to eliminate safety risk



Install make-up air, such as a passive inlet vent, or other pressure relief



After mitigation, verify that depressurization limit is not being exceeded

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



Unsafe

Neglect of clothes dryer maintenance can cause fire hazards



Best Practice

Occupants should be taught to clean lint filters and termination fittings

6.6005.2b

Desired Outcome:

Kitchen range fan installed to specification

Specification(s):

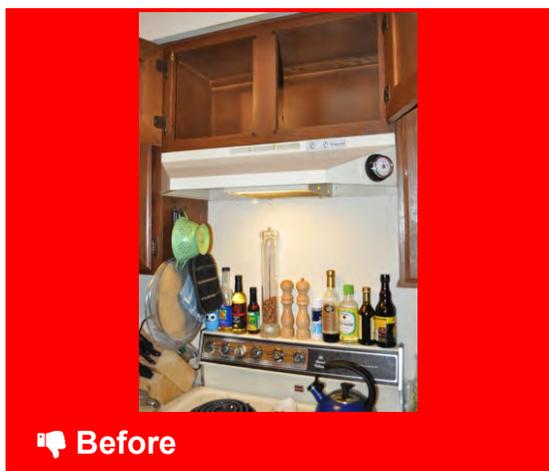
Kitchen range fans will be vented to the outdoors

Recirculating fans will not be used as a ventilating device

Objective(s):

Remove cooking contaminants from the house

Preserve integrity of building envelope



Recirculating fans over ranges do not actually remove contaminants



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 connections 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 connections 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



 Before

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



 After

Daylight visible through dampered kitchen exhaust proves outside access

Tools:

1. Drill
2. Metal snips
3. Saw
4. Putty knife
5. Tape measure
6. Disposable brushes
7. Wire cutters
8. Scissors

Materials:

1. Round metal ducting
2. Mastic
3. Fiberglass mesh tape
4. Fasteners
5. Galvanized wire to secure insulation onto ductwork
6. Nylon webbing for hanging ducts
7. UL-181 foil or Mylar tape to seal seams in insulation vapor barrier

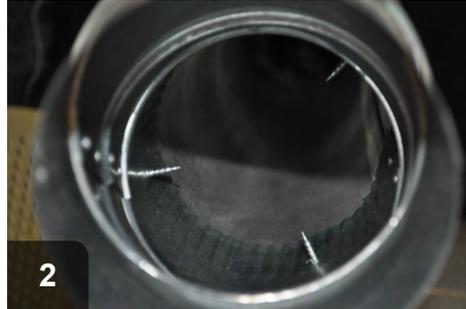
See also 6.6002.4d. Note: Only smooth-wall metal duct will be used, except for down-draft exhaust systems where PVC is acceptable as well. Flex duct is NOT acceptable for kitchen fan exhaust application.

From the Manufactured Housing SWS: Ducts installed outside of the thermal [envelope](#) will be insulated to a minimum of R-8 or in accordance with local codes.

6.6005.2c - Fan ducting



1
Duct run should be as smooth and short as possible



2
Duct should be fastened securely with three evenly-spaced screws



3
Then joints should be secured with fiberglass tape



4
Coat joint with UL-181 mastic, at least 0.08" (2mm) thick



5
Wrap duct with R-8 insulation. Seal seams in insulation vapor barrier with UL-181 listed foil or Mylar tape

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

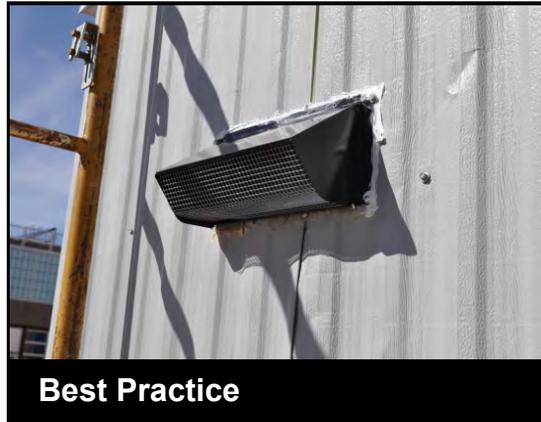
Objective(s):

Ensure safe operation of combustion appliances

Ensure occupant health and safety



Kitchen exhaust termination fitting should include a backdraft damper



A screen can also help to discourage vermin infiltration

6.6005.2e

Desired Outcome:

Kitchen range fan installed to specification

Specification(s):

Makeup air will be provided for kitchen range fans exhausting more than 200 CFM

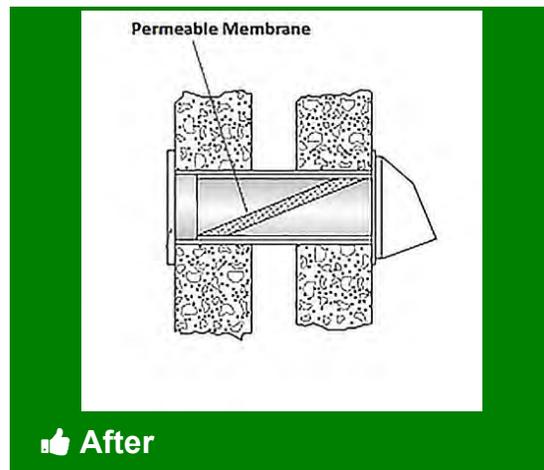
Objective(s):

Ensure safe operation of combustion appliances

Ensure occupant health and safety



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

Tools:

1. Drill
2. Hole saw
3. Caulk gun

Materials:

1. Caulk sealant
2. Fasteners

6.6205.1a

Desired Outcome:

Provide primary ventilation for common spaces

Specification(s):

Assessment will be done using ASHRAE 62.2 standard:

- Blower door test
- Fan flow measurements
- Calculations

Objective(s):

Determine the ventilation needs of the whole house

In Progress

A calculation based on pre and post Wx numbers should be performed to determine the amount of ventilation needed.

6.6205.1b

Desired Outcome:

Provide primary ventilation for common spaces

Specification(s):

Fan type will be capable of continuous operation and selected in accordance with ASHRAE 62.2 for:

- Sizing
- Climate considerations
- Control strategy
- Sone rating
- Durability

Fan will be ENERGY STAR qualified

Objective(s):

Determine proper fan selection

Minimize energy consumption during fan operation



Fans should be marked with the ENERGY STAR logo.

Sone Rating Limits of 62.2			
	Local Exhaust (SPOT) INTERMITTENT	Local Exhaust (SPOT) CONTINUOUS	WHOLE BUILDING
New Fans	3.0	1.0	1.0
Existing Fans	N/A	N/A	1.0

No sone requirement when.....

- Using an existing fan with a timer
- Remote mounted fans (i.e. inline fan in the attic)

Best Practice

6.6205.1c

Desired Outcome:

Provide primary ventilation for common spaces

Specification(s):

No resistance greater than 3 pascals will exist between fan intake location with reference to the common area

Exhaust ventilation for common spaces will not be installed in bathrooms or bedrooms

Objective(s):

Ensure fresh air distribution to common areas



Tools:

1. digital manometer

6.6205.1c - Location



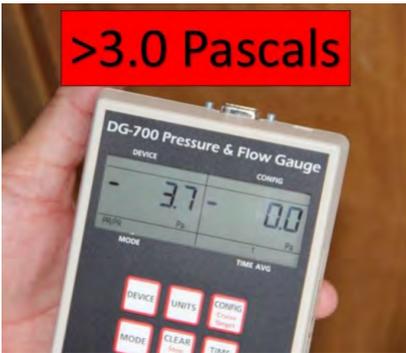
Locate the fan in question.



Connect a hose, and turn the manometer on to PR/PR.



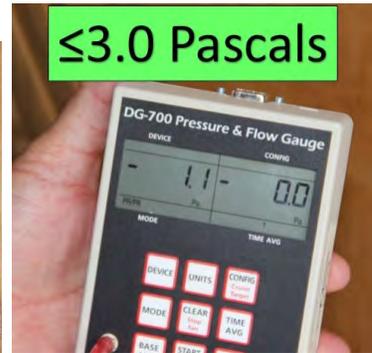
Turn on the exhaust fan.



If the pressure difference is greater than 3.0 pascals, pressure relief is needed.



If pressure relief is needed, it can be provided by a through the door transfer grille.



After pressure relief has been provided recheck the numbers, ensuring a reading within range.

6.6205.1d

Desired Outcome:

Provide primary ventilation for common spaces

Specification(s):

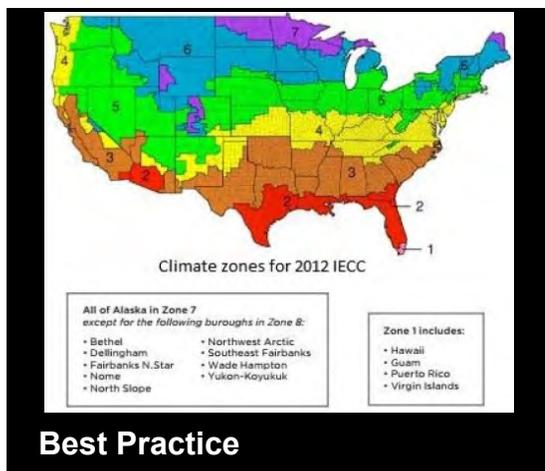
ASHRAE 62.2 will be referenced for climate considerations

Whole house mechanical net exhaust flow for hot-humid climate will not exceed 7.5 cubic feet per minute/100 square feet

Objective(s):

Maintain building durability

Protect occupant health



Best Practice

Climate should be considered when selecting a ventilation strategy. Hot humid climate zones require special attention.

6.6205.1f

Desired Outcome:

Provide primary ventilation for common spaces

Specification(s):

Occupant will be educated on:

- Purpose of the ventilation system
- Proper operation and use of controls
- Cost and benefit of system
- Manual shut off

A label indicating the presence and purpose of the ventilation system will be included or a copy of the system operation guide will be posted at the electrical panel

Operation guide or label will be permanently attached and in full sight

Objective(s):

Ensure occupant is educated on the safe and efficient operation of the system

Deliver intended air exchange



Clients should be educated on the purpose and operation of their new ventilation system.



Whole house ventilation should be clearly labeled.

6.6205.1g

Desired Outcome:

Provide primary ventilation for common spaces

Specification(s):

Total exhaust system airflow will be measured

Objective(s):

Ensure exhaust airflow is as designed



In Progress

Measure the fan flow with the flow meter.

Tools:

1. digital manometer
2. exhaust fan flow measuring device

6.6288.2a

Desired Outcome:

Systems operate as quietly as possible

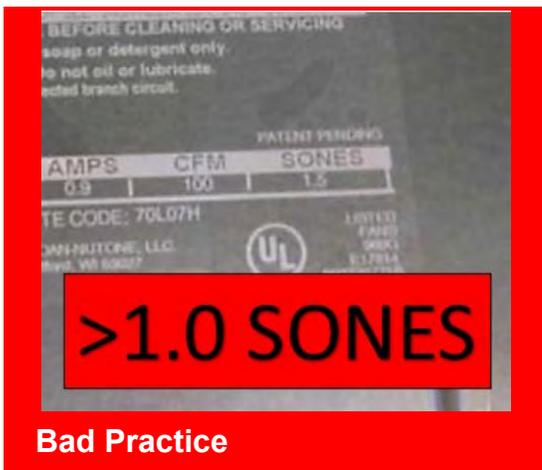
Specification(s):

System will be rated at a sound no greater than 1.0 sone

Objective(s):

Minimize noise

Maximize fan use



This fan is rated at 1.5 SONES and is NOT acceptable for continuous use.



This fan is rated at 1.0 sones and is acceptable for continuous use.

6.6288.2b

Desired Outcome:

Systems operate as quietly as possible

Specification(s):

Spot ventilation (local mechanical exhaust systems operated as needed by the occupant; e.g., range hood, bath fans) will be rated at a sound no greater than 3.0 sone

Objective(s):

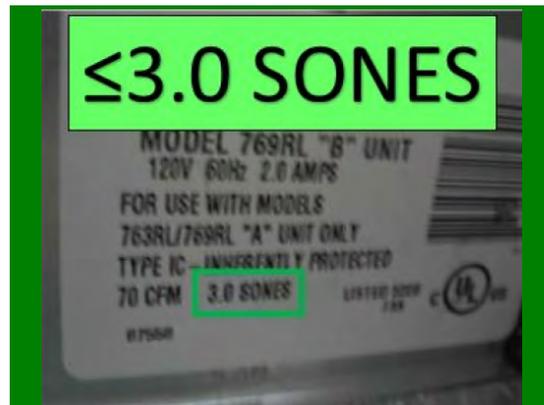
Minimize noise

Maximize fan use



Bad Practice

This fan is rated at 3.5 SONES and is NOT acceptable for intermittent use.



Best Practice

This fan is rated at 3.0 sones and is acceptable for intermittent use.

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 industry acceptable standards, 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

Expansion tank is installed on the cold water supply side

Appropriate licensing for installer required. Expansion tanks are only required to be installed only when in conjunction with new and replacement water heaters and only if required by authority having jurisdiction.

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 industry acceptable standards and according to manufacturer specifications

Temperature and pressure relief valve discharge tube will be installed in accordance with industry acceptable standards

Objective(s):

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



 Before

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



 After

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

Tools:

1. Pipe wrench
2. Hacksaw

Materials:

1. PVC
2. Plumber's epoxy

Check local jurisdictional codes. 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.

7.8102.2i

Desired Outcome:

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

Specification(s):

If additional tank insulation is installed, it will be rated a minimum of R-11 and will be installed to manufacturer specifications

The first 6' of inlet and outlet piping will be insulated in accordance with manufacturer specifications

Objective(s):

Reduce standby loss from near tank piping and storage tank



 Before

Uninsulated storage-type water heater



 After

Storage-type water heater with additional insulation

7.8102.2i - Thermal efficiency



1 Clean the entire outside of the water heater



2 Wrap blanket around tank and mark it where it overlaps. Add two or three inches and cut off using a straightedge and raz



3 Cut the insulation off at the mark. Peel away the excess insulation, leaving a flap of vapor barrier



4 Pull insulation blanket around the tank



5 Staple the flap to the blanket with outward clinching staples or use long zip ties to secure the blanket in place



6 Cut out around drain valve, P&T relief valve, and thermostats. Do not cover combustion access or air supply on gas units



7 Use remaining insulation for the top of electric water heaters. Tape up seams in the vapor barrier. Insulate water lines

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



Unsafe

Water heaters producing water over 120 degrees raise heating costs



Safe

Water heaters should produce water under 120 degrees to prevent scalding

Tools:

1. Thermometer

7.8102.3d

Desired Outcome:

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

Specification(s):

An emergency drain pan will be installed with sides that extend a minimum of 4" above floor if leakage would cause damage to the home and/or in accordance with industry acceptable standards

A ¾" drain line or larger will be connected to tapping on pan and terminated or in accordance with industry acceptable standards

Objective(s):

Collect and safely dispose of water escaping from the storage tank



Emergency drain pan with drain piped to outside

Tools:

1. PVC cutters
2. Tongue-and-groove pliers

Materials:

1. 4" deep drain pan
2. ¾" or 1" PVC drain fittings and pipe
3. PVC cement

7.8102.3h

Desired Outcome:

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

Specification(s):

Any accessible hot water lines at the appliance will be insulated to in accordance with industry acceptable standards

Objective(s):

Reduce line losses



Insulate accessible pipes to R-3 or better

Materials:

1. Foam pipe insulation
2. Spray adhesive
3. Zip ties

Hot water pipe insulation requirements are found in Chapter 11 of the International Residential Code, Section N1103.4.2 (R403.4.2). The code calls for a minimum of R-3. As a best practice, R-4 and R-5 pipe insulation is available through mechanical and industrial suppliers.

Maintain proper clearances from the water heater vent when installing foam pipe insulation.

7.8102.3i

Desired Outcome:

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

Specification(s):

Recommendations will be made to install all on-demand appliances as sealed combustion

If not possible:

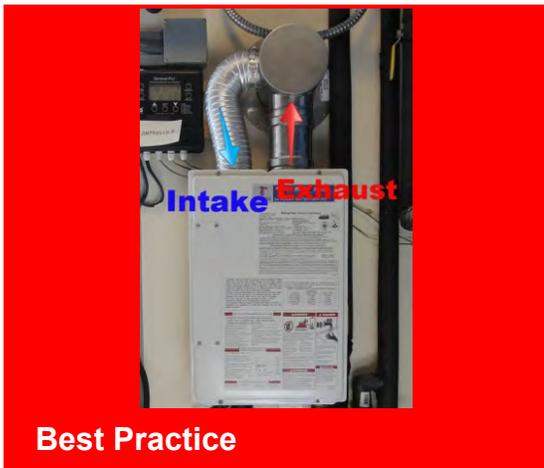
Combustion and ventilation (excess air) requirements of gas-fired appliances, including provision of outside and inside air to account for building tightness, will be provided

The minimum required volume shall be 50 cubic feet per 1,000 Btu/h

If needed, additional combustion air will be provided in accordance with industry acceptable standards

Objective(s):

Ensure adequate combustion air for operation of the appliance



Best Practice

Best practice is to install on-demand water heaters as direct-vent units



If not installed as direct vent, refer to notes and images on next page for required combustion air

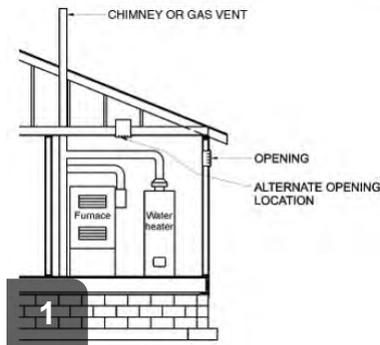
To determine adequate combustion air: add up the input Btus of all combustion appliances in the space and divide by 20. The result is the minimum required air volume in cubic feet (50 cubic feet per 1,000 input Btus). If the available volume is less than 50 cubic feet per 1,000 input Btus, provide additional combustion air as listed below for each circumstance

Image 1: For homes with one permanent opening: a minimum free area of 1 in² per 3,000 Btu/h (734 mm²/kW) of total input rating of all appliances

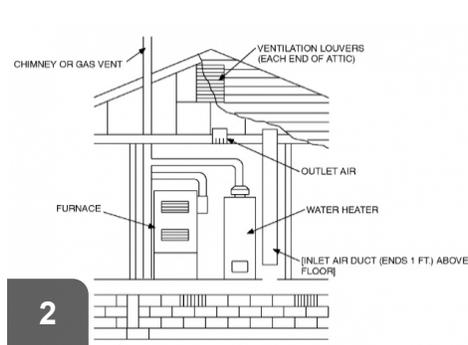
Image 2: For homes with two permanent vertical duct openings: a minimum free area of 1 in² per 4,000 Btu/h (550 mm²/kW) of total input rating of all appliances

Image 3: For homes with two permanent horizontal duct openings: a minimum free area of 1 in² per 2,000 Btu/h (1,100 mm²/kW) of total input rating of all appliances

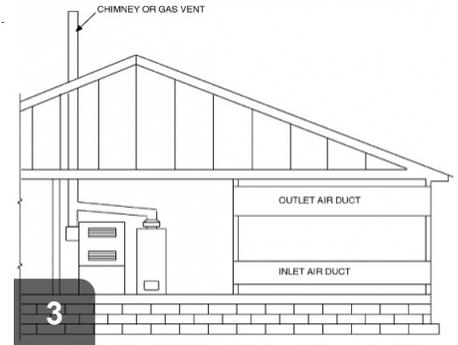
7.8102.3i - Required combustion air



min free area of 1 sqin per 3,000 Btu/h (734 mm²/kW) of total input rating



min free area of 1 sqin per 4,000 Btu/h (550 mm²/kW) of total input rating



min free area of 1 sqin per 2,000 Btu/h (1100 mm²/kW) of total input rating

7.8102.3j

Desired Outcome:

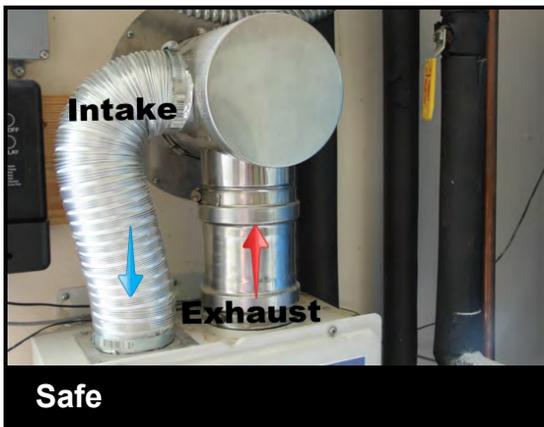
Safe and reliable hot water source provided that meets occupant needs at lowest possible cost of ownership

Specification(s):

Combustion byproducts will be removed in accordance with industry acceptable standards and manufacturer specifications

Objective(s):

Ensure the safety and durability of the venting system



On-demand water heater combustion air intake and exhaust vent, interior view

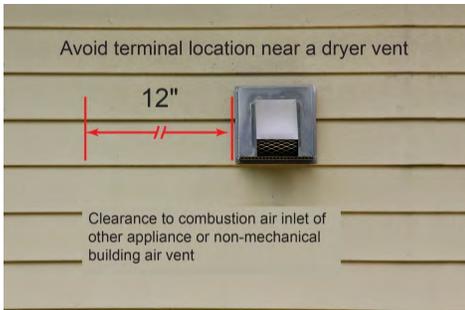


On-demand water heater combustion air intake and exhaust vent

Follow manufacturer's venting instructions for on-demand appliances. Local codes may be more stringent than the International Residential Code (Section G2407), which governs venting of gas appliances,

Do not locate vent terminals near dryer vents.

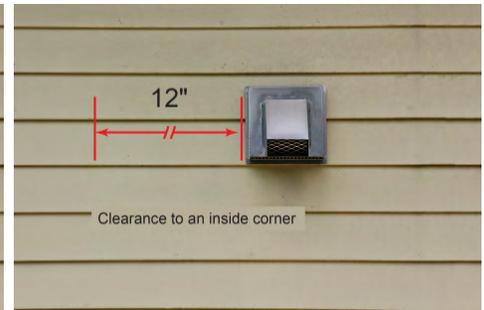
7.8102.3j - Venting of flue gases



Leave 12" between a vent terminal and any non-mechanical building vent or combustion air inlet from another appliance



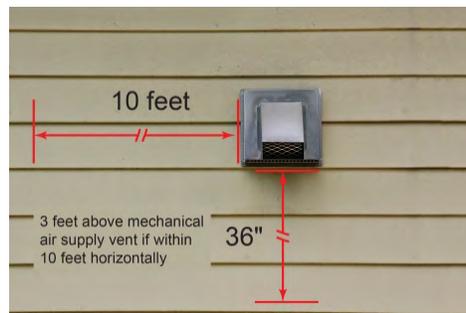
Leave 12" between vent terminals and any operable door or window



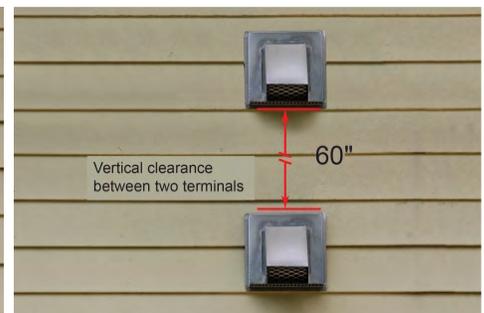
Allow 12" clearance from the edge of a vent to any inside corner of the building



Allow 12" between any two vent terminals



Install vent terminal at least 3 feet higher than any mechanical air inlet that is closer than 10 feet away horizontally



Leave 60" between terminals that are in line vertically



Install vent terminals at least 36" below any eave, soffit, porch, or deck within 24 horizontal inches of center of vent



Install vent at least 36" above grade, porch, deck, veranda, or snow line

7.8102.3k

Desired Outcome:

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

Specification(s):

Undiluted flue gases will be checked with a calibrated combustion analyzer in accordance with BPI-1100-T-2012

If combustion is not in compliance with BPI-1100-T-2012, diagnostics and adjustments will be done to manufacturer specifications or local codes

Objective(s):

Confirm that combustion is occurring safely with maximum efficiency



Test flue gases with properly calibrated equipment

Tools:

1. Properly calibrated combustion analyzer

The combustion analyzer shall be calibrated in accordance with the manufacturer's recommendations with available documentation traceable to the individual device.

7.8102.3p

Desired Outcome:

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

Specification(s):

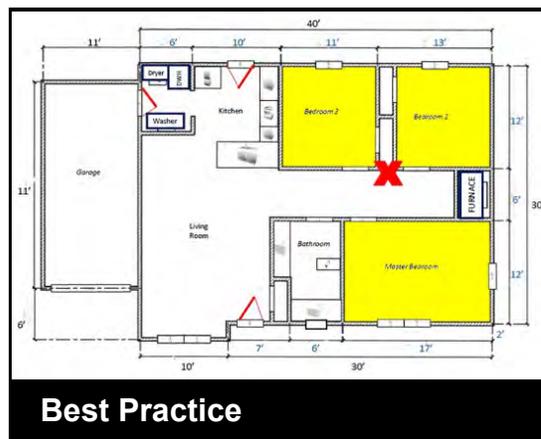
All homes with combustion appliances or an attached garage will have a carbon monoxide (CO) alarm

Objective(s):

Ensure occupant health and safety



Carbon Monoxide alarms should be installed according to local codes



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

Tools:

1. Drill/screwdriver

Materials:

1. CO alarm
2. Fasteners

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

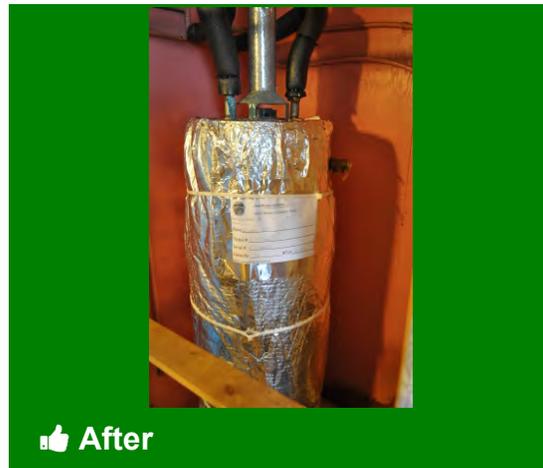
Electrical components will be verified to comply with NEC (e.g., no electrical box connector, no disconnect, improperly sized breaker and wire)

Objective(s):

Identify potential health and safety issues



Complete combustion safety testing to ensure healthy, safe work environment



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

Tools:

1. Personal CO monitor
2. Combustion analyzer with probe
3. Manometer
4. Smoke pencil
5. Mirror
6. Stopwatch, timer, or watch with second hand

Materials:

1. CO alarm
2. Fasteners

See also SWS 2.0201.2a-2.0299.1i for all Combustion Safety details and SWS 2.0602.2c for Electrical Safety.

7.8103.1b

Desired Outcome:

Safe, reliable, and efficient operation of the appliance maintained

Specification(s):

Inspection will be conducted to show compliance with the industry acceptable standards, including but not limited to:

- Water or fuel leaks
- Damaged wiring
- Venting issues with draft and condensation (e.g., soot, rusting of flue pipe, burned paint or wires, efflorescence)
- Corrosion (e.g., rust, mineral deposits)
- General condition of components

Objective(s):

Determine needed repairs or maintenance



In Progress

Inspect for rust, corrosion, and dust around draft diverter. Verify diverter is centered and fastened. Check T&P valve



In Progress

Inspect for signs of flame rollout, thermostat and gas valve condition, and proper T&P relief valve termination

Tools:

1. Flashlight
2. Inspection mirror

7.8103.2a

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 NFPA 70 National Electric Code (e.g., no electrical box connector, no disconnect, improperly sized breaker and wire)

Objective(s):

Identify potential health and safety issues



Safe

On-demand water heater



Best Practice

Check carbon monoxide levels in the appliance vent

Tools:

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

Materials:

1. CO alarm
2. Fasteners

See also SWS 2.0201.2a-2.0299.1i for all Combustion Safety details and SWS 2.0602.2c for Electrical Safety.

7.8103.2b

Desired Outcome:

Safe, reliable, and efficient operation of the appliance maintained

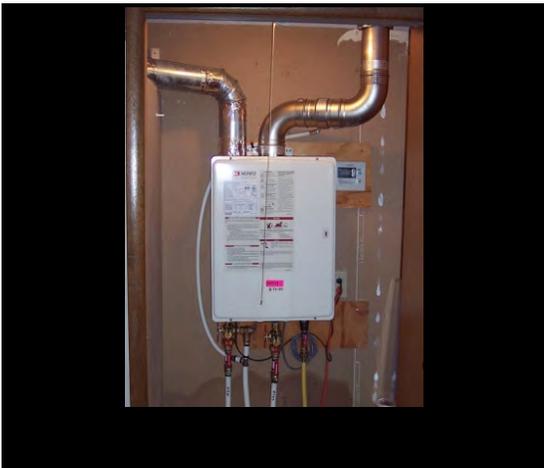
Specification(s):

Inspection will be conducted to show compliance with industry acceptable standards, including but not limited to:

- Water or fuel leaks
- Damaged or missing pipe insulation and tank insulation, where applicable
- Damaged wiring
- Venting issues with draft and condensation (e.g., soot, rusting of flue pipe, burned paint or wires, efflorescence)
- Corrosion (e.g., rust, mineral deposits)
- General condition of components

Objective(s):

Determine needed repairs or maintenance



Check installation and ensure it meets manufacturer's instructions and local codes

7.8103.2b - Visual inspection



Inspect for rust, corrosion, and dust around draft diverter. Verify diverter is centered and fastened. Check T&P valve



Check draft diverter alignment



Inspect for rust, corrosion, and leaks



Inspect for signs of flame rollout, thermostat and gas valve condition, and proper T&P relief valve termination

7.8103.2g

Desired Outcome:

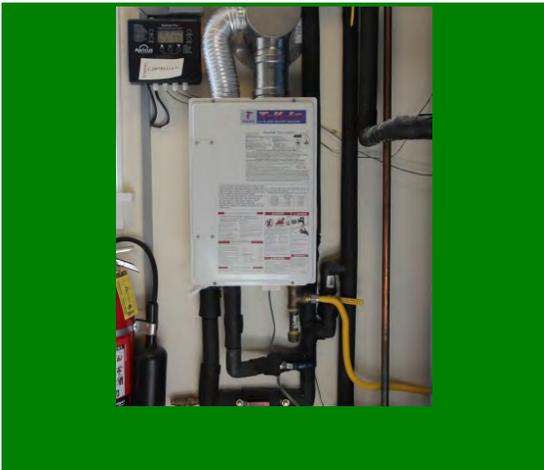
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):

Condition of fuel supply components will be checked in accordance with NFPA 31 for oil, NFPA 54 for gas, NFPA 58 for propane, or NFPA 70 National Electric Code for electric, and authority having jurisdiction

Objective(s):

Verify sufficient fuel to the water heater burner and element



Inspect fuel supply and verify that sizing and capacity are correct

Tools:

1. Flashlight

7.8103.2g - Fuel supply



Inspect gas lines for corrosion, leaky fittings, worn flex lines, sediment traps and drip legs, and kinked copper



Inspect LP gas tanks for corrosion, proper location, leaky fittings, and kinked or damaged copper