Retrofitting Maryland - 2018 MH

Standard Work Specifications

Field Guide for

Manufactured Housing

created by

Maryland Department of Housing and Community Development

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2.0100.1 - Global Worker Safety

Desired Outcome:
Work completed safely without injury or hazardous exposure

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

2.0100.1a - Prevention through design

Desired Outcome:
Work completed safely without injury or hazardous exposure

Specification(s):
Design will be incorporated to eliminate or minimize hazards (e.g., material selection, access to equipment for installation and maintenance, placement of equipment, ductwork and condensate lines)

Objective(s):
Prevent worker injuries

Reduce risk exposure to toxic substances and physical hazards

2.0100.1b - Hand protection

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 hazards

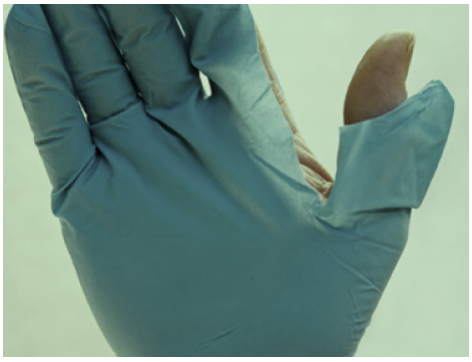
Unsafe

Recognize potential risks

Safe

Wear appropriate hand protection

GOOD: Wear nitrile gloves when handling mastic



Inspect gloves for holes and damage to minimize risk

2.0100.1c - Respiratory protection

Desired Outcome:
Work completed safely without injury or hazardous exposure

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

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

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

Consult MSDS for respiratory protection requirements

OSHA 1910.134 shall be followed for the implementation of a respiratory protection program

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

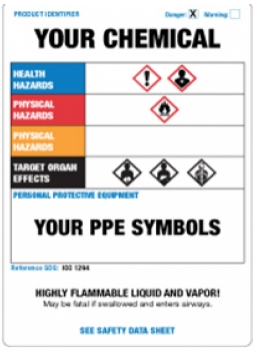
When web-enabled, click link to read [OSHA 1910.134]

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



When unsure what level of protection

spray foam, use a Supplied Air Respirator

is necessary, check the Safety Data Sheets (SDS) for the materials to be used

2.0100.1d - Electrical safety

Desired Outcome:
Work completed safely without injury or hazardous exposure

Specification(s):
An electrical safety assessment will be performed

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

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

Worn or frayed electrical cords will not be used

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

Metal ladders will be avoided

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

Aluminum foil products will be kept away from live wires

For arc flash hazards, NFPA 70E will be consulted

Objective(s):
Avoid electrical shock and arc flash hazards

Inspect house for unsafe electrical situations

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

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

Recognize if knob and tube wiring is present and take special precautions

Follow NFPA 70E guidelines for arc flash hazards

2.0100.1e - Carbon monoxide (CO)

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):
All homes will have a carbon monoxide alarm

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

Objective(s):
Protect worker and occupant health

Unsafe

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

Best Practice

Install carbon monoxide alarms in all homes

Tools:

1. CO meter

2.0100.1f - Personal Protective Equipment

Desired Outcome:
Work completed safely without injury or hazardous exposure

Specification(s):
MSDS and OSHA regulations will be consulted for equipment and protective clothing would be worn if contaminants are present(e.g., insulation materials)

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

Before

Workers should be aware of work required and dress appropriately

After

Ensure workers have proper protective equipment for work environment and materials

2.0100.1g - Confined space safety

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):
Prevent build-up of toxic or flammable contaminants

Reduce risk to the workers in the confined space

Provide adequate access and egress points

Prevent electrical shock

Best Practice

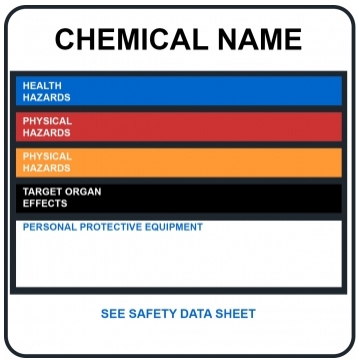
Locate all access and egress points of confined spaces before entering

Best Practice

Perform visual inspection of confined spaces before beginning work

Check for frayed or worn electrical wires

In confined spaces, use a ventilator to provide fresh air



Check GHS labels and Safety Data Sheets for all materials to minimize hazards

2.0100.1h - Power tool safety

Desired Outcome:
Work completed safely without injury or hazardous exposure

Specification(s):
Power tools will be inspected and used in accordance with manufacturer specifications and OSHA regulations to eliminate hazards such as those associated with missing ground prongs, ungrounded circuits, misuse of power tools, noise, and improper or defective cords or extension cords.All tools must be maintained in proper operating condition with all guards securely in place

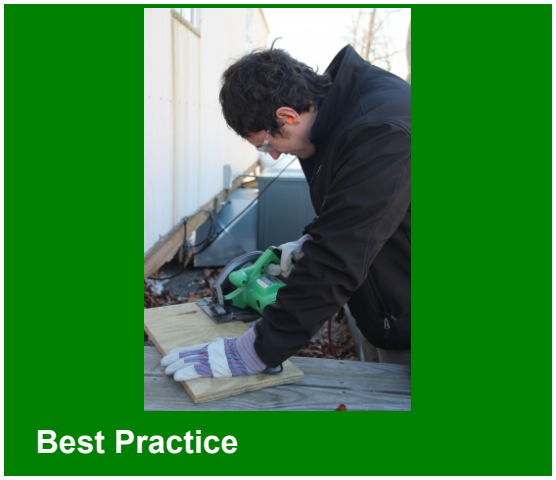
All devices used will be verified as GFCI protected or double insulated

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

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



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

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.

2.0100.1i - Chemical safety

Desired Outcome:
Work completed safely without injury or hazardous exposure

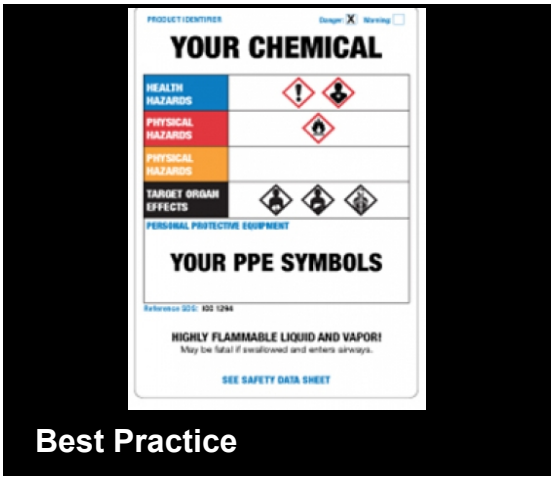
Specification(s):
Hazardous materials will be handled in accordance with manufacturer specifications, MSDS and OSHA standards to eliminate hazards associated with volatile organic compounds (VOCs), sealants, insulation, contaminated drywall, dust, foams, asbestos, lead, mercury, and fibers

Appropriate personal protective equipment (PPE) will be provided

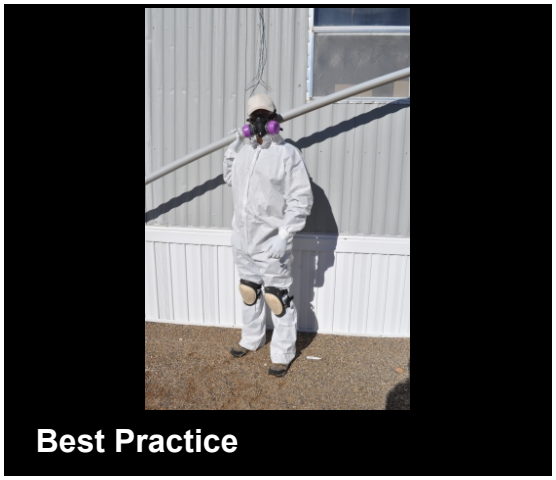
Workers will be trained on how to use PPE

Workers will be expected to always use appropriate PPE during work

Objective(s):
Prevent worker exposure to toxic substances



New GHS/SDS labeling is clear and concise--workers should be familiar with how to read new Safety Data Sheets



Workers should be trained on how to wear PPE, be provided with proper PPE, and know when to use it

2.0100.1j - Ergonomic safety

Desired Outcome:
Work completed safely without injury or hazardous exposure

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

Proper equipment will be used for work

Proper lifting techniques will be used

Objective(s):
Prevent injuries from awkward postures, repetitive motions, and improper lifting

Workers will take precautions to protect themselves on the job site

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

Tools:

1. Hard hats
2. Knee pads
3. Bump caps

When web-enabled, visit https://www.osha.gov/SLTC/ergonomics/controlhazards.html for additional guidance.

2.0100.1k - Hand tool safety

Desired Outcome:
Work completed safely without injury or hazardous exposure

Specification(s):
Hand tools will be maintained in safe working order and used for intended purpose

Objective(s):
Prevent injuries

2.0100.1l - Slips, trips, and falls

Desired Outcome:
Work completed safely without injury or hazardous exposure

Specification(s):
Caution will be used around power cords, hoses, tarps, and plastic sheeting

Precautions will be taken when ladders are used, when working at heights, or when balancing on joists

Walk boards will be used when practical

When scaffolding is used, manufacturer set-up procedures will be followed

Appropriate footwear and clothing will be worn

Objective(s):
Prevent injuries due to slips, trips, and falls

2.0100.1m - Thermal stress

Desired Outcome:
Work completed safely without injury or hazardous exposure

Specification(s):
Ensure staff is aware of risks during extreme weather including the symptoms of heat stroke, heat exhaustion, and hypothermia

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 and the cold

DO NOT HESITATE to call 911 in potential cases of heat stroke or hypothermia

Tools:

1. Cool vests
2. Ventilator

Set up temporary ventilation in hot attics before beginning work, and always use the buddy system.

- If gable vents are present, attach portable fans to them to exhaust hot, contaminated air and draw in fresh, cool air from the house, or
- Set up inline fans in the house and run flexible trunks into the attic to supply fresh, cool air
- Designate a person on the ground to monitor the safety of attic workers
- Rotate personnel out of hot attics frequently to avoid overheating

Keep workers comfortable with hydration and cool vests

Provide fresh and moving air when working in hot confined spaces

2.0100.1n - Fire safety

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 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 should be removed from the work area with the permission and/or assistance of the homeowner

Best Practice

Set combustion appliances to off or pilot to minimize risk of fire

2.0100.1o - Asbestos-containing materials (ACM)

Desired Outcome:
Work completed safely without injury or hazardous exposure

Specification(s):
Assess potential asbestos hazard; if unsure whether material contains asbestos, contact a qualified asbestos professional to assess the material and to sample and test as needed

If suspected ACM is in good condition, do not disturb

If suspected ACM is damaged (e.g., unraveling, frayed, breaking apart), immediately isolate the area(s)

For suspected ACM that is damaged or that must be disturbed as part of the retrofit activity, contact an asbestos professional for abatement or repair in accordance with federal, state, and local requirements; only a licensed or trained professional may abate, repair, or remove ACM

When working around ACM, do not:

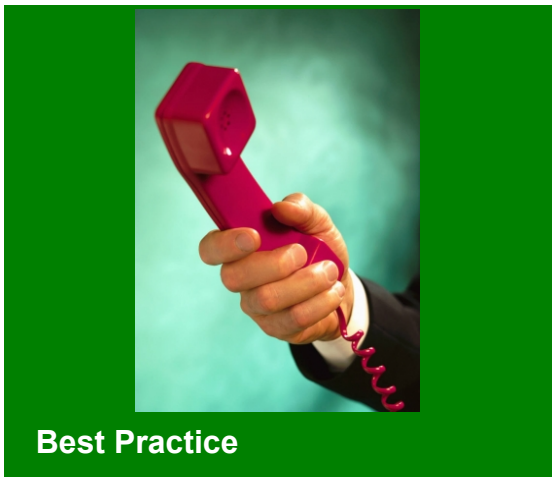
- Dust, sweep, or vacuum ACM debris
- Saw, sand, scrape, or drill holes in the material
- Use abrasive pads or brushes to strip materials

Asbestos abatement or repair work should be completed prior to blower door testing; exercise appropriate caution when conducting blower door testing where friable asbestos or vermiculite attic insulation is present to avoid drawing asbestos fibers into the living space (i.e., use positively

pressurized blower door testing) unless the material has been tested and found not to contain asbestos

Objective(s):
Protect workers and occupants from potential asbestos hazards

If materials that may contain asbestos are found in the home, do not disturb the material or run blower door



If asbestos is suspected, call an EPA-accredited professional

Materials:

1. Containment shroud
2. Caution tape

Do not disturb ACM by vacuuming, dusting, or sweeping

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

2.0100.1p - Lead paint assessment

Desired Outcome:
Work 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

Best Practice

In homes built before 1978, test paint before beginning renovation or assume presence of lead

Tools:

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

Materials:

1. Cleaning solution or cleaning wipes
2. Bag or folded paper to catch debris

EPA RRP certification required to conduct Lead Paint assessment.

Clean tools and sample site to prevent contamination

Place catchment bag under sample site to catch any debris. Cut sample site at an angle to expose all older paint layers

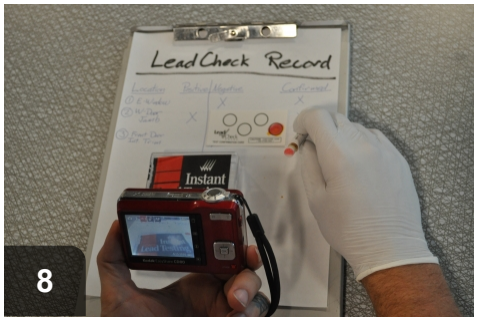
Break capsules and shake to mix reagents. Swab sample site for 30 seconds

Check swab for reaction

Red indicates lead positive. White is lead negative

If negative, verify validity of test with provided calibration card

Lead in calibration card should test positive and turn spot red



Record test results to maintain documentation

2.0100.1q - Site security

Desired Outcome:

Work completed safely without injury or hazardous exposure

Specification(s):
Work site will be secured to prevent unauthorized entry

Temporarily disconnected eqipment will be locked up and tagged out

All loose or unbagged trash and unused materials will be removed from work site daily

Objective(s):
Protect the occupant from exposure to potential hazards

2.0100.1r - Crawl space safety

Desired Outcome:
Work completed safely without injury or hazardous exposure

Specification(s):
The source of all contaminants (e.g., sewage,dead animals,needles) will be corrected,repaired,or removed before performing inspections that require complete access to the crawl space

If appropriate, the contaminant will be neutralized and/or a protective barrier will be installed in the area

Objective(s):
Ensure work safety

Prevent worker exposure to hazards

2.0102.1 - Insulation Worker Safety

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

2.0102.1a - Worker safety

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

Specification(s):
Woker safety specifications will be followed in accordance with SWS 2.0100 Global Worker Safety

Objective(s):
Prevent injury

Minimize exposure to health and safety hazards

2.0102.1b - Asbestos containing materials (ACM)

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

Specification(s):
OSHA asbestos abatement protocol 29 CFR 1926.1101 will be followed if vermiculite insulation is present

Assess potential asbestos hazard; if unsure whether material contains asbestos, contact a qualified asbestos professional to assess the material, and to sample and test as needed

If suspected ACM is in good condition, do not disturb

If suspected ACM is damaged (e.g., unraveling, frayed, breaking apart), immediately isolate the area(s)

For suspected ACM that is damaged or that must be disturbed as part of the retrofit activity, contact an asbestos professional for abatement or repair, in accordance with federal, state, and local requirements; only a licensed or trained professional may abate, repair, or remove ACM

When working around ACM, do not:

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

Asbestos abatement or repair work should be completed prior to blower door testing; exercise appropriate caution when conducting blower door testing where friable asbestos or vermiculite attic insulation is present to avoid drawing asbestos fibers into the living space (i.e., use positively pressurized blower door testing) unless the material has been tested and found not to contain asbestos

Objective(s):
Protect workers and occupants from potential asbestos hazards

If materials that may contain asbestos are found in the home, do not disturb the material or run blower door

If asbestos is suspected, call an EPA-accredited professional

Materials:

1. Containment shroud
2. Caution tape

Do not disturb ACM by vacuuming, dusting, or sweeping

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

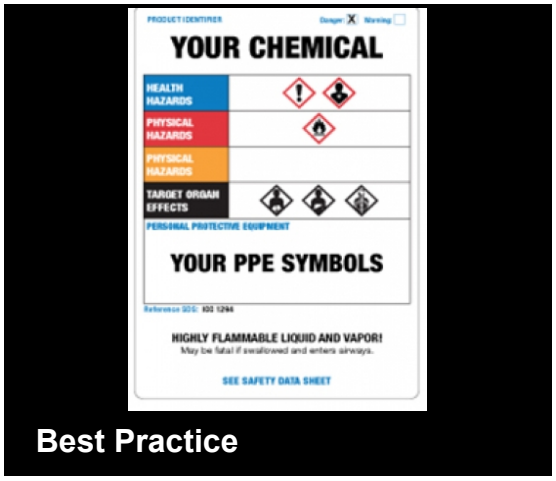
2.0102.1c - Materials

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

Specification(s):
All materials will be handled in accordance with manufacturer specifications or material safety data sheets (MSDS) standards

Objective(s):
Eliminate hazards associated with incorrect, defective, or improperly used or installed materials

Workers should be familiar with Safety Data Sheets for materials used and know where to locate SDS in case of emergency



New Safety Data Sheet and GHS label formatting is easier to quickly interpret

2.0102.1d - Lead paint assessment

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 rule making or any more stringent state or federal standards

Objective(s):
Protect worker and occupant from potential lead hazards

Best Practice

In homes built before 1978, test paint before beginning renovation or assume presence of lead

Tools:

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

Materials:

1. Cleaning solution or cleaning wipes
2. Bag or folded paper to catch debris

EPA RRP certification required to conduct Lead Paint assessment.

Clean tools and sample site to prevent contamination

Place catchment bag under sample site to catch any debris. Cut sample site at an angle to expose all older paint layers

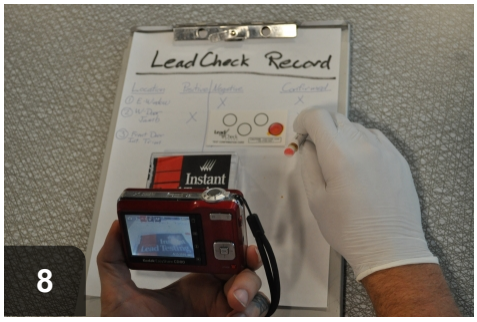
Break capsules and shake to mix reagents. Swab sample site for 30 seconds

Check swab for reaction

Red indicates lead positive. White is lead negative

If negative, verify validity of test with provided calibration card

Lead in calibration card should test positive and turn spot red



Record test results to maintain documentation

2.0103.2 - Heating and Cooling Worker Safety

Desired Outcome:
Work completed safely without injury or hazardous exposure

2.0103.2a - Worker safety

Desired Outcome:
Work completed safely without injury or hazardous exposure

Specification(s):
Follow all worker safety specifications in SWS 2.0100 Global Worker Safety section

Objective(s):
Prevent injury

Minimize exposure to health and safety hazards

2.0103.2b - Mercury

Desired Outcome:
Work completed safely without injury or hazardous exposure

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

Objective(s):
Protect 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.

2.0103.2c - Asbestos

Desired Outcome:
Work completed safely without injury or hazardous exposure

Specification(s):
Suspected asbestos hazards will be identified in furnaces (e.g., gaskets), wood stoves, zonal heating devices, electrical wiring insulation, boilers, and pipe insulation and corrected in accordance with EPA guidance

Workers will take precautionary measures to avoid exposure

Objective(s):
Protect worker and occupant from asbestos exposure

Unsafe

Have an AHERA-certified professional test all areas with suspected asbestos. Remediate in accordance with EPA rules.

2.0103.2d - Personal protective equipment (PPE)

Desired Outcome:
Work completed safely without injury or hazardous exposure

Specification(s):
Workers will wear personal protective equipment (PPE) as needed to protect themselves against exposure to hazards (e.g., pests, sewage, flooded duct work, mold, chemicals, scat, viruses)

Long sleeves and long pants should be worn as additional protection from liquid nitrogen and other hazardous materials

Objective(s):
Protect worker from exposure to hazards

Protect worker from skin contact with liquid nitrogen

Unsafe

When working with refrigerants, short sleeves are inappropriate

Safe

When working with refrigerants, workers should dress appropriately

Wear work gloves when working with metal ducts

Assess the site and situation to determine proper PPE to minimize risks

2.0103.2e - Combustible gas detection

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

Fuel leaks need to be repaired

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

Paraphrased from 2012 IRC G2417: 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.

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 - Carbon monoxide (CO)

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

Test for CO in entire home, particularly around combustion appliances

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

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

2.0103.2g - Sealant

Desired Outcome:
Work completed safely without injury or hazardous exposure

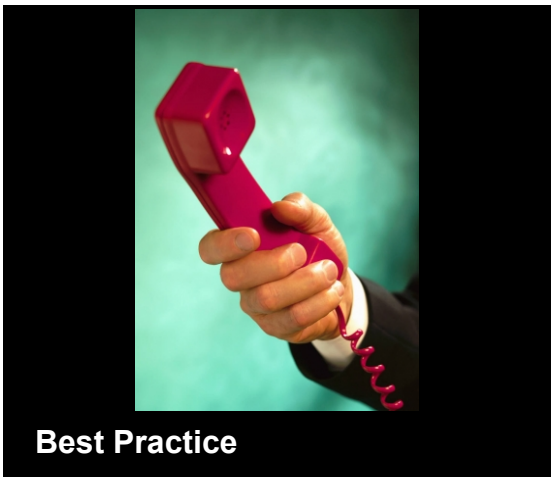
Specification(s):
Pipes will be sealed by a certified professional with an approved fastening process and sealant in accordance with manufacturer specifications (International Fuel Gas Code)

Gas lines will be leak free when tested with an electronic combustible gas leak detector and verified with bubble solution

OR

Gas lines will be leak free when tested by a standing pressure test that meets the approval of the local code

Objective(s):
Install gas lines with no leaks



Call a licensed professional for gas line installations and repairs.

Test any new gas line connections with combustible gas detector, and verify lack of leaks with testing solution

Tools:

1. Combustible gas detector
2. Testing solution

2.0103.2h - Safety devices

Desired Outcome:
Work completed safely without injury or hazardous exposure

Specification(s):
A secondary LP safety detector system (valve, exhaust fan, alarm light) will be installed by a certified professional for propane piping installed below grade

When installing new equipment, a shut off valves will be installed by a certified professional at each gas appliance (ANSI Z21.15)

Objective(s):
Detect accumulation of dangerous levels of propane in below-grade areas

Isolate appliances from the rest of the system for emergencies, removal, or repairs

Best Practice

Call a certified professional

2.0107.5 - Prework Qualifications (Home Installation)

Desired Outcome:
Manufactured home is properly installed

2.0107.5a - Installation deficiencies

Desired Outcome:
Manufactured home is properly installed

Specification(s):
Any installation deficiencies that may affect worker safety or integrity or installed measures will be repaired before starting work

Objective(s):
Ensure site is safe and ready for upgrade

Unsafe

The concrete pad is not centered under the pier, rendering the pier susceptible to tilting or collapse

Safe

Approved, properly installed piers, anchors, and tie downs

Tools:

1. Level
2. Cordless driver drill
3. Flashlight

Inspect homes for safety before work. Look for stuck doors and windows, buckled siding, and loose tie-downs as evidence of settling. Inspect piers to ensure that they are solid and level. Check for loose or missing wooden shims and wedges. Inspect anchors and straps for tightness and proper installation per manufacturer's recommendations.

Carefully inspect the foundation piers. Look for loose or missing shims and wedges

2.0107.5b - Stabilization

Desired Outcome:
Manufactured home is properly installed

Specification(s):
Home must be stabilized in accordance with manufacturer specifications or local authority having jurisdiction

Objective(s):
Ensure the home is secured properly

Prevent injury

Minimize exposure to health and safety hazards

Unsafe

Unstable mobile homes are unsafe work environments. Do not crawl under mobiles that are not stabilized

Safe

Properly stabilized homes have a solid foundation and have anchored straps, unless otherwise indicated by manufacturer

2.0201.1 - Combustion Appliance Zone (CAZ) Testing

Desired Outcome:
Accurate information about appliance safe operation is gathered

2.0201.1a - Assessment

Desired Outcome:
Accurate information about appliance safe operation is gathered

Specification(s):
Emergency problems (e.g., ambient gas levels greater than 10% Lower Explosion Limit (LEL), ambient CO levels that exceed 70 ppm) will be communicated clearly and immediately to the customer, the home shall be evacuated, and appropriate personnel (e.g.: HVAC technician, utility, emergency services) shall be contacted. ;

Significant problems (e.g., gas leak less than 10% LEL, ambient CO levels that exceed 35 ppm but less than 70 ppm) will be communicated clearly and immediately to the customer and appropriate solutions will be suggested

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

Objective(s):
Ensure system does not have potentially 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

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 - Fuel leak detection

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

Fuel lines should be inspected for leakage

2.0201.1a

Tools:

1. Gas sniffer
2. Spray bottle

Materials:

1. Bubble solution

Paraphrased from 2012 IRC G2417: 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.

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 - Venting

Desired Outcome:

Accurate information about appliance safe operation is gathered

Specification(s):

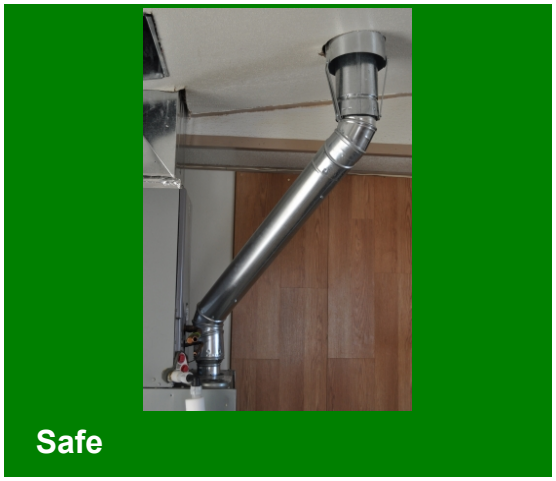
For oil systems that require a draft regulator, the presence and operability of it (that draft regulator) will be verified and tested

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

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

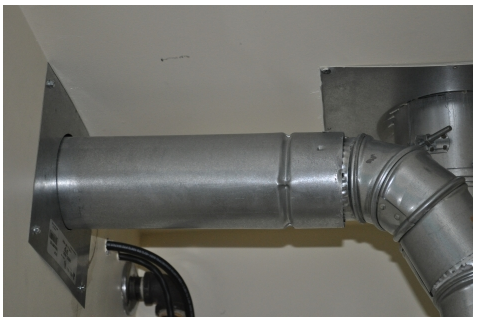


Properly vented appliances make a house healthier and more efficient

Determine if a draft regulator is installed and working

Inspect venting systems for damage

Inspect venting systems for disconnected pipes



Inspect venting systems for inadequate slope

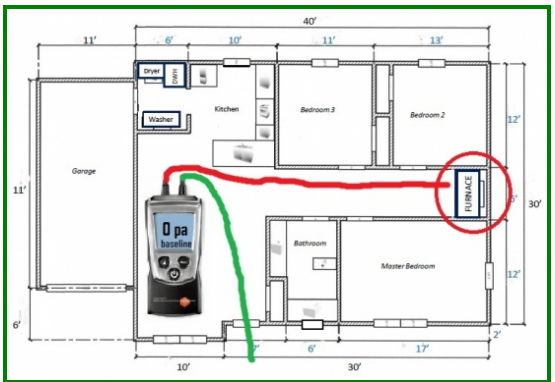
Inspect for missing draft diverter

2.0201.1d - Base pressure test

Desired Outcome:
Accurate information about appliance safe operation is gathered

Specification(s):
Baseline pressure for naturally drafting vented appliances will be measured in Combustion Appliance Zone with reference to outdoors

Objective(s):
Measure pressure difference between combustion zone and the outside under natural conditions



Best Practice

Natural conditions--Winter set-up, Exhaust fans off, Interior doors open

Tools:

1. Manometer

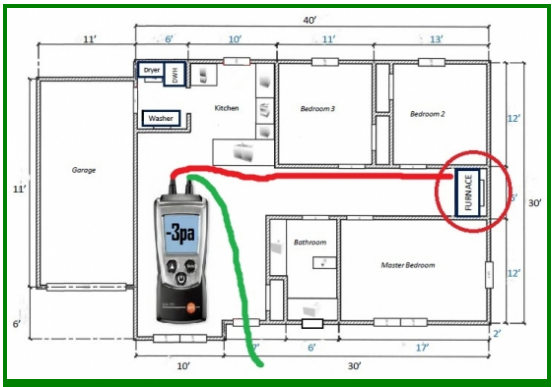
2.0201.1e - Depressurization test

Desired Outcome:
Accurate information about appliance safe operation is gathered

Specification(s):
CAZ depressurization testing will be administered for all atmospherically vented appliances located inside the pressure boundary.

Depressurization test will include exhaust fans, interior door closure, or duct leakage, or a combination thereof; the test will be done to determine the largest negative pressure per BPI Standard 1200.

Objective(s):
Determine worst-case depressurization in combustion zone due mechanical system fans

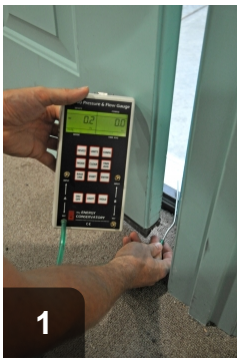


Best Practice

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

Tools:

1. Manometer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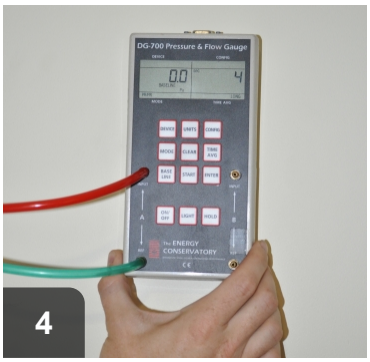
3

Place manometer reference hose to exterior of house

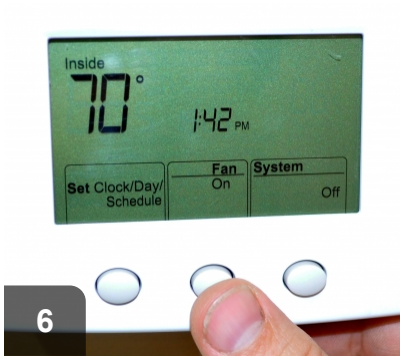
Attach test hose to be used in the interior of the house

Place test hose by combustion appliance



Take baseline reading

Turn on interior exhaust fans, including any clothes dryers



Is the air handler on?

Check interior doors for pressure differential either using smoke pencil or hand

Check reading against the Depressurization Limits table. If reading is less negative than allowable limit, all is well

2.0201.2 - Combustion Safety - Make-up Air

Desired Outcome:
Buildup of dangerous combustion byproducts in the living space prevented

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

2.0201.2a - Outside combustion make-up air

Desired Outcome:
Buildup of dangerous combustion byproducts in the living space prevented

Specification(s):
Where applicable, combustion air will be provided from the outside and installed in accordance with the IRC for the type of appliance installed

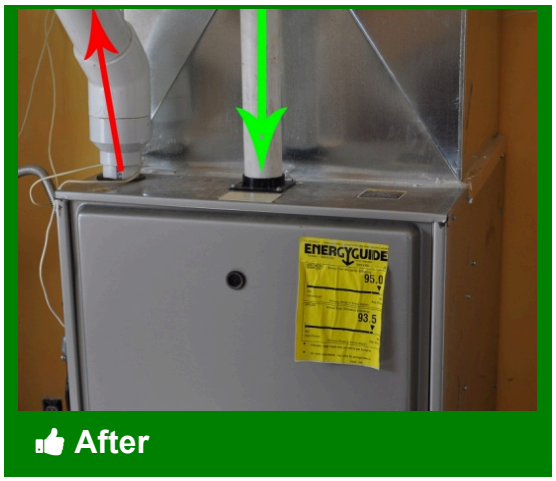
Objective(s):
Prevent combustion byproducts from entering the house

2.0201.2b - New appliances

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 if possible. New appliances will be installed in accordance with manufacturer specifications, the IRC and additional applicable codes
Objective(s):
Prevent combustion byproducts from entering the house

Damaged combustion appliances beyond repair should be replaced



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

Two-pipe 90% efficiency furnaces are viable replacement appliances

Direct vent combustion appliances are also viable replacements

2.0201.2c - CO detection and warning equipment

Desired Outcome:
Buildup of dangerous combustion byproducts in the living space prevented

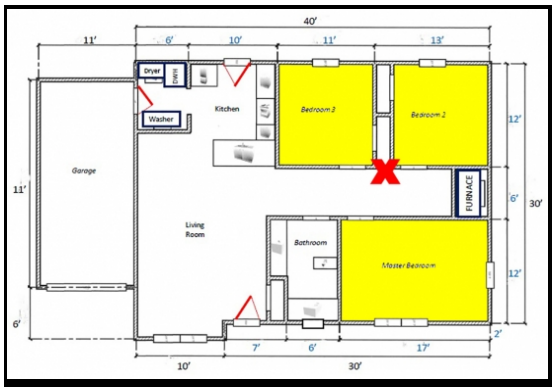
Specification(s):
CO detection or warning equipment will be installed outside of each separate sleeping area in the immediate vicinity of the bedrooms in accordance with ASHRAE 62.2 and authority having local jurisdiction

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 in all homes



Best Practice

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

Tools:

1. Drill

Materials:

1. CO alarm
2. Fasteners

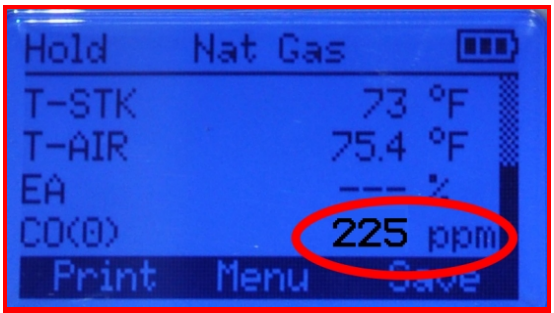
2.0201.2d - Gas ovens

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



Unsafe

If air-free CO reading exceeds 225ppm, order a clean and tune

After

Test gas oven for carbon monoxide using a combustion gas analyzer

Tools:

1. Combustion analyzer with probe

2.0201.2e - Gas range burners

Desired Outcome:
Buildup of dangerous combustion byproducts in the living space prevented

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

Objective(s):
Ensure clean burn and operation of gas range burners

Before

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

After

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

Gas ranges should be cleaned and tuned if improper operation is evident

2.0201.2f - Solid fuel burning appliances

Desired Outcome:
Buildup of dangerous combustion byproducts in the living space prevented

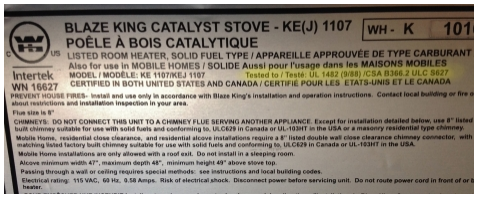
Specification(s):
If the solid fuel burning appliance is the primary heat source and has signs of structural failure replace solid fuel burning appliance with UL-listed and EPA - certified appliances if the existing appliance is not UL-listed

Objective(s):
Ensure safe operations of solid fuel burning appliances

Unsafe solid fuel burning appliances should be replaced

New appliances should be UL-listed and EPA-certified

Locate data plate to find out appliance ratings



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

2.0201.3 - Vented Combustion Appliance Safety Testing

Desired Outcome:
Accurate information about appliance safe operation is gathered

2.0201.3a - Spillage Test

Desired Outcome:
Accurate information about appliance safe operation is gathered

Specification(s):
In conditions with largest negative pressure as determined from Detail 2.0201.1e:

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

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

Objective(s):
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

BPI 1200 states that spillage should not exceed one minute.

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

Desired Outcome:
Accurate information about appliance safe operation is gathered

Specification(s):
CO will be tested for in undiluted flue gases of combustion appliances

In conditions with largest negative pressure as determined from Detail 2.0201.1e:

If CO levels exceed 400 ppm air-free measurement in furnaces, service will be provided to reduce CO to below these levels (unless CO measurement is within manufacturer specifications)

If CO levels exceed 200 ppm air-free measurement in water heaters or room heaters, service will be provided to reduce CO to below these levels (unless CO measurement is within manufacturer specifications)

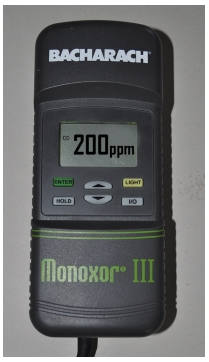
Objective(s):
Measure CO and report excessive levels

CO levels cannot exceed 200ppm as measured, unless to manufacturer specs

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

Tools:

1. Combustion analyzer with probe



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

Test undiluted flue gases in induced-draft furnaces--check local codes before drilling

Test undiluted flue gases in natural draft water heaters

Test accessible exhaust outlets for direct-vent appliances

Test accessible exhaust outlets for power-vented appliances

2.0201.3c - Final test out

Desired Outcome:
Accurate information about appliance safe operation is gathered

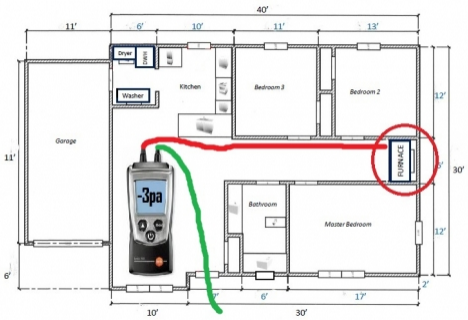
Specification(s):
Final combustion testing will be conducted at project completion to ensure compliance with the above specifications

Objective(s):
Ensure safe operation of combustion appliance within the whole house system after any repair project

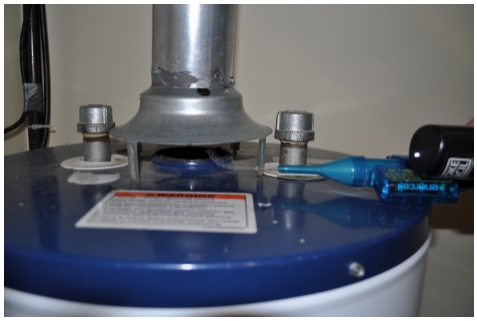
Conduct spillage and depressurization testing at the end of the work day

Tools:

1. Manometer
2. Smoke pencil
3. Timer



Run depressurization test at the end of the work day



Complete spillage test using chemical smoke pencil

Test for spillage on all sides of draft diverter

Complete spillage testing on all combustion appliances

Complete carbon monoxide testing using a CO detector

2.0202.1 - Unvented Space Heaters: Propane, Natural Gas, and Kerosene Heaters

Desired Outcome:
Elimination of combustion byproducts

2.0202.1a - Removal

Desired Outcome:
Elimination of combustion byproducts

Specification(s):
With the occupant's permission, unvented heaters will be removed, except when used as a secondary heat source and when it can be confirmed that the unit is listed to ANSI Z21.11.2

Units that are not being operated in compliance with ANSI Z21.11.2 should be removed before the retrofit but may remain until a replacement heating system is in place

Failure to remove unvented space heaters serving as primary heat sources has the potential to create hazardous conditions, and thus any further weatherization services will be reevaluated in the context of potential indoor air quality risks

Objective(s):
Eliminate sources of combustion byproduct within a living space

Unvented space heaters should be removed with the occupants' permission

Unvented space heaters can be replaced with properly vented space heaters

Secure permission to remove unvented space heaters from occupants

Ensure new combustion appliances are vented properly

2.0202.1b - Occupant education

Desired Outcome:
Elimination of combustion byproducts

Specification(s):
Occupant will be educated on potential hazards of unvented combustion appliances (primary or secondary) within a living space

Objective(s):
Inform occupant about possible hazards associated with combustion byproducts and moisture

Unsafe

Unvented space heaters in homes are hazardous to occupants

Best Practice

Clearly communicate the hazards to the occupant in order to inform their decision to remove the appliance

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

2.0203.1 - Combustion Air for Natural Draft Appliances

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

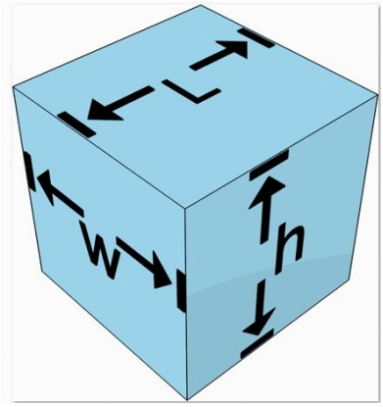
2.0203.1a - Required combustion air

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

Specification(s):
The required volume of indoor air will be determined in accordance with IRC and authority having jurisdiction, except that where the air infiltration rate is known to be less than 0.40 air changes per hour (ACH), IRC will be used

Exception: Existing appliances that have passed combustion safety testing per BPI 1200 are deemed to have sufficient combustion air

Objective(s):
Determine if existing conditions meet the combustion air calculation



Best Practice

G2407.5.1 (304.5.1) Standard method. The minimum required volume shall be 50 cubic feet per 1,000 *Btu*/h (4.8 m3/kW).

G2407.5.2 (304.5.2) Known air-infiltration-rate method. Where the air infiltration rate of a structure is known, the minimum required volume shall be determined as follows: For purposes of this calculation, an infiltration rate greater than 0.60 ACH shall not be used in Equations 24-1.

For *appliances* other than fan assisted, calculate volume using Equation 24-1.

Required Volume(natural draft) ≥((21ft3/ACHn)(Input(other)/1,000BTU/hr))*

Input(other) = All appliances other than fan assisted (input in Btu/h).

ACHn = Air change per hour under natural conditions

Standard: 100,000 BTUH Furnace Input 100,000 x .05 = 5,000ft3or 100,000/1000 = 100. 100 x 50 = 5,000ft3

Known infiltration rate method(assuming ACHn is .50 in this example): ((21ft3/.50)*(100,000/1,000BTU/hr)) = 4,200ft3

Measure the CAZ width.

Measure the CAZ length.

Measure the CAZ height.

2.0203.1b - Additional combustion air (if action is required)

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

Specification(s):
Additional combustion air will be provided in accordance with IRC and authority having jurisdiction when necessary to solve spillage problems

Objective(s):
Ensure adequate combustion air for operation of the appliance

Combustion appliances in a confined space

Additional combustion air supplied from high/low vents

Tools:

1. Drywall saw
2. Drill
3. Tin snips
4. Tape measure
5. Wire cutters

Materials:

1. Metal ducts
2. 1/4" galvanized hardware cloth mesh
3. Galvanized straps or L-brackets to secure high/low vents
4. Screws
5. Louvered grilles (optional)
6. Louvered doors (optional)

Combustion appliances require 50 cubic feet of volume for every 1,000 Btuh input. If this is not available, provide makeup air in accordance with the IRC G.2407 or local code.

When high/low vents are used, use two metal ducts each having 1 in2 of cross-sectional area for every 4,000 Btuh input. Extend each into the attic above the insulation level, and use 1/4" galvanized hardware cloth mesh on top to screen out insects and vermin. Terminate one vent within 12" of the ceiling, and one vent within 12" of the floor. The vents may be concentric (one inside the other) to save space, so long as the difference between the area of the larger and smaller vents is equal to or greater than the 1 in2/4,000 Btuh requirement.

If using a single large opening in the ceiling, make the opening total 1 in2 per 3,000 Btuh input.

If high/low vents extend horizontally through a CAZ wall, use vents with 1 in2 of area per 2,000 Btuh of input.

Louvered grilles or doors may be used to connect the CAZ to larger sections of the home to achieve the required volume, but be aware that using this approach has higher potential for creating a carbon monoxide pathway into the home than does creating a sealed CAZ with high/low vents.

Select vent sizes based on the total input Btus in the CAZ. Concentric vents are shown

Cut hole in ceiling and mount high/low vents to framing

Fasten 1/4" galvanized hardware cloth over high/low vent openings

Complete installation by adding supports and fasteners as required for stability and durability

Terminate the low vent within 12" of the floor. This one is mounted inside a section of larger diameter metal duct

2.0203.1c - Spillage testing

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

Specification(s):
If spillage in a combustion appliance with a warm vent exceeds two minutes during pressure testing, specify measures to mitigate

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

Objective(s):
Detect excessive spillage of combustion gases

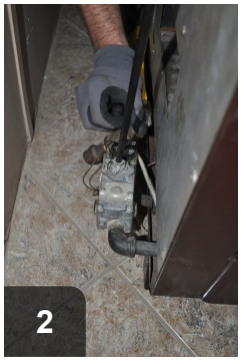
Natural draft appliances should be tested for spillage

Spillage should not exceed 2 minutes, if present

Tools:

1. Smoke pencil
2. Stopwatch or timer

Inspect appliance for evidence of damage or unsafe operation before testing



Fire up appliance in order to test

Test for spillage--should not exceed 2min. If 2min are exceeded, mitigate.

2.0203.2 - Combustion Flue Gas—Orphaned Water Heaters

Desired Outcome:
Flue gasses successfully removed from the house

2.0203.2a - Spillage testing

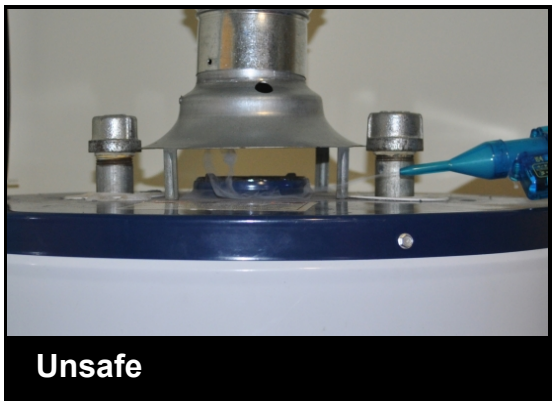
Desired Outcome:
Flue gasses successfully removed from the house

Specification(s):
If spillage in a combustion appliance with a warm vent exceeds two minutes during pressure testing, specify measures to mitigate

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

Objective(s):
Detect excessive spillage of combustion gases

Orphaned water heaters have oversized flues after a furnace is removed



Spillage should not exceed 2 minutes, if present

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

Desired Outcome:
Flue gasses successfully removed from the house

Specification(s):

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

Objective(s):

Allow water heater to vent properly

Prevent damage to the chimney

Before

Unlined masonry chimney

After

Flue liner with rain cap

Tools:

1. Hammer drill
2. Disposable brushes
3. Tin snips
4. 5/16" nut driver
5. Pulling cone
6. Rope
7. Caulking gun
8. Tape measure
9. 4 1/2" angle grinder with metal cutoff wheel

Materials:

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

Connect chimney liner to appliance in accordance with applicable codes.

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

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

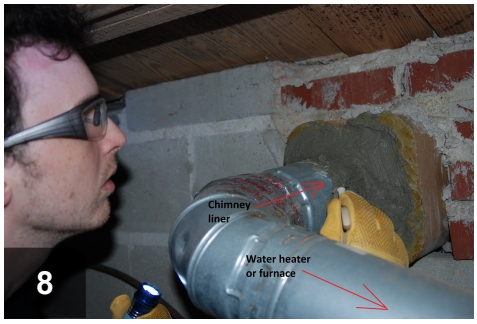
Measure and mark the flexible chimney liner at 4 inches above the chimney

Cut the flexible chimney liner to length

Install top plate over opening and attach it to the liner

Fasten the rain cap to the chimney liner

Seal around penetrations in chimney with refractory (furnace) cement



Connect appliance vent to the chimney liner

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

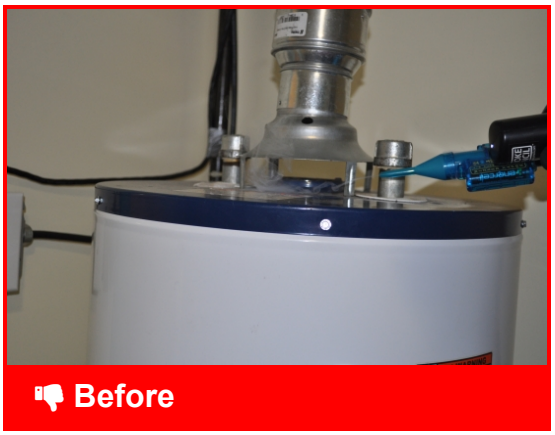
2.0203.2c - Retesting spillage

Desired Outcome:

Flue gasses successfully removed from the house

Specification(s):
If a combustion appliance spillage exceeds two minutes during pressure testing, specify measures to mitigate

Objective(s):
Ensure appliance is not spilling longer than two minutes with a warm vent



If spillage continues to exceed 2 min, additional repairs are required

Repipe the flue to eliminate the oversized chimney. After repairs, spillage should no longer occur beyond 2 minutes

Tools:

1. Smoke pencil
2. Timer

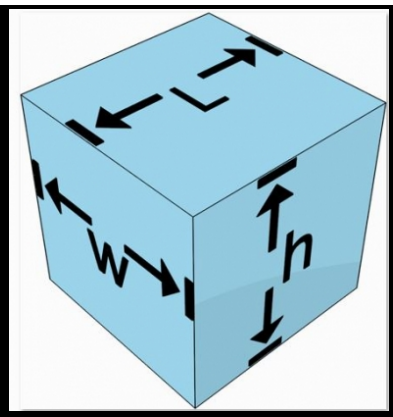
2.0203.2d - Required combustion air

Desired Outcome:
Flue gasses successfully removed from the house

Specification(s):
The minimum required volume will be 50 cubic feet per 1,000 Btu /h in accordance with IRC and authority having jurisdiction.

Exception: Existing appliances that have passed combustion safety testing per BPI 1200 are deemed to have sufficient combustion air.

Objective(s):
Determine if existing conditions meet the combustion air calculation



Best Practice

If measured volume is less than 50cuft per 1000Btuh, additional combustion air is needed.

Safe

If appliances have passed combustion safety testing per BPI 1200, no additional combustion air is needed.

Tools:

1. Measuring tape
2. Calculator

Measure the CAZ width.

Measure the CAZ length.

Measure the CAZ height.

2.0203.2e - Additional combustion air (if action is required)

Desired Outcome:
Flue gasses successfully removed from the house

Specification(s):
Additional combustion air will be provided in accordance with IRC or other authority having jurisdiction

Objective(s):
Ensure adequate combustion air for operation of the appliance

Combustion appliances in a confined space

Additional combustion air supplied from high/low vents

Tools:

1. Drywall saw
2. Drill
3. Tin snips
4. Tape measure

Materials:

1. Metal ducts
2. 1/4" galvanized hardware cloth mesh
3. Galvanized straps or L-brackets to secure high/low vents
4. Screws
5. Louvered grilles
6. Louvered doors

Combustion appliances require 50 cubic feet of volume for every 1,000 Btuh input. If this is not available, provide makeup air in accordance with the IRC G.2407 or local code

Select vent sizes based on the total input Btus in the CAZ. Concentric vents are shown

Cut hole in ceiling and mount high/low vents to framing

Fasten 1/4" galvanized hardware cloth over high/low vent openings

Complete installation by adding supports and fasteners as required for stability and durability

Terminate low vent within 12" of the floor. This one is fastened to a section of larger diameter duct for stability

2.0203.4 - Occupant Education

Desired Outcome:
Ensure persistence of resident safety

2.0203.4a - Occupant health and safety

Desired Outcome:
Ensure persistence of resident safety

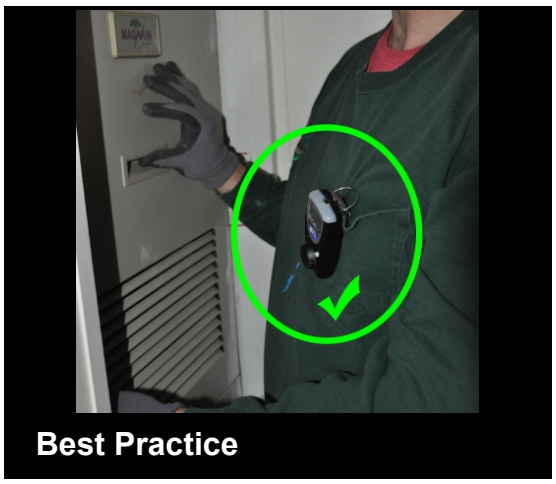
Specification(s):
All homes will have a functioning CO alarm

If CO levels in interior living spaces exceed outdoor levels, potential sources will be investigated and appropriate action taken to reduce them (e.g., have a qualified professional tune, repair, or replace improperly operating combustion appliances; apply weather stripping or conduct air sealing between the garage or crawl space and the home)

Objective(s):
Ensure occupant health and safety

Ensure indoor CO levels do not exceed outdoor CO levels

ALL houses must have carbon monoxide detectors installed near sleeping areas



Compare indoor and outdoor CO levels. In case of elevated indoor CO levels, locate the source and fix the problem

Tools:

1. Combustion analyzer with probe
2. Personal CO monitor

Test all combustion appliances for co exhaust and check against appropriate action levels for appliance type

Do not forget to test gas ovens as a potential source of CO -- check results against action levels

If combustion appliances are source of elevated CO levels, repair or replace as necessary

Could CO infiltration be coming from outdoor sources? Air seal and weatherstrip to minimize outdoor pollutants

2.0203.4b - Occupant education

Desired Outcome:
Ensure persistence of resident safety

Specification(s):
Occupants will be educated on the operation and maintenance of the CO alarm

Completed work on combustion appliances and recommended maintenance will be reviewed with occupant

Occupant will be provided information regarding the health effects and risk of high CO concentrations; EPA provides possible expanded actions and offers client education information in an appendix to the protocols

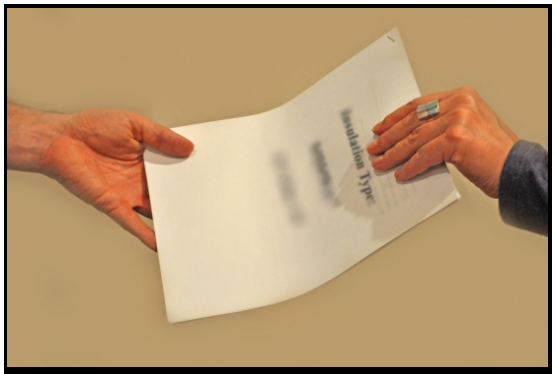
Objective(s):

Ensure occupant can operate and maintain installations

Inform occupant regarding possible CO hazards

Best Practice

Review CO alarm maintenance with occupant



Best Practice

Provide occupant with information about CO sources, risks, and symptoms

2.0204.1 - Isolating Combustion Water Heater Closet

Desired Outcome:
Isolate combustion water heater closet from conditioned space

Note:

2.0204.1a - Work assessment

Desired Outcome:
Isolate combustion water heater closet from conditioned space

Specification(s):
Installer prework assessment will be conducted to determine:

- Combustion safety
- Proper venting
- Structural integrity
- Roof leaks
- Insect infestation
- Accessibility
- Number, type, size, and location of penetrations

Objective(s):
Ensure combustion appliance is functioning safely

Ensure work space is safe and ready for air sealing

Verify scope of work

2.0204.1b - Air seal closet

Desired Outcome:
Isolate combustion water heater closet from conditioned space

Specification(s):
When the water heater closet contains a heater that is not sealed combustion or power vented, the closet will be isolated/separated from the rest of the home through air sealing with fire-rated materials, if feasible

Avoiding frozen pipes must be considered without creating an additional utility burden (e.g., heat tape)

Objective(s):
Prevent combustion gases from entering living area and minimize extension of interior pressures caused by exhaust fan, dryers, and interior door closure into the water heater closet

2.0204.1c - Materials

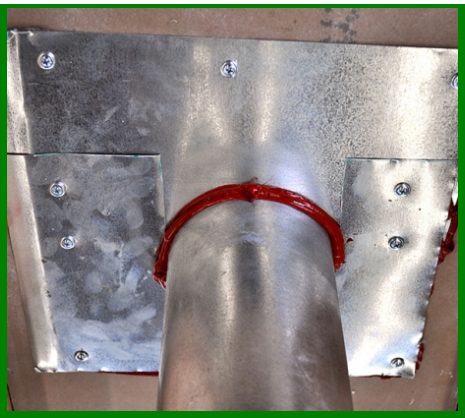
Desired Outcome:
Isolate combustion water heater closet from conditioned space

Specification(s):
Only noncombustible materials will be used in contact with chimneys, vents, and flues

Objective(s):
Prevent a fire hazard

Best Practice

When sealing around combustion flue penetrations, use appropriate materials



After

26-gauge steel sheeting and high temp caulk should be used to seal around flue

Tools:

1. Caulk gun
2. Metal snips
3. Drill

Materials:

1. High-temperature caulk
2. 26-gauge steel sheeting
3. Fasteners

2.0204.1d - Post-work testing/verification

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

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.

2.0301.1 - Smoke Alarm

Desired Outcome:
Properly installed smoke alarms

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

2.0301.1a - Smoke alarm (hardwired)

Desired Outcome:
Properly installed smoke alarms

Specification(s):
When installing hardwired smoke alarms, it will be listed and labeled in accordance with UL 217 and installed in accordance with the IRC or as required by the authority having jurisdiction

Objective(s):
Ensure proper installation

Hard-wired smoke alarm mount with alarm missing

Hard-wired smoke alarm mount with alarm replaced

When web-enabled, click link for IRC R314 on Smoke Alarm locations. All homes should have smoke alarms installed near every sleeping area and on each story.

2.0301.1b - Smoke alarm (battery operated)

Desired Outcome:
Properly installed smoke alarms

Specification(s):
When installing battery operated smoke alarms, it will be installed in accordance with manufacturer specifications

Objective(s):
Ensure proper installation

All homes should have UL-217 rated smoke alarms

Paraphrased from 2012 IRC R314: Smoke alarms will be permitted to be battery operated when installed in buildings without commerical power or when alterations or repairs do not result in the removal of interior wall or ceiling finishes exposing the structure to provide access for hard-wiring, unless there is an attic, crawl space, or basement available with could provide access.

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

2.0301.2 - Carbon Monoxide Alarm or Monitor

Desired Outcome:
Properly installed CO alarms or monitors

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

2.0301.2a - CO detection and warning equipment (hardwired)

Desired Outcome:
Properly installed CO alarms or monitors

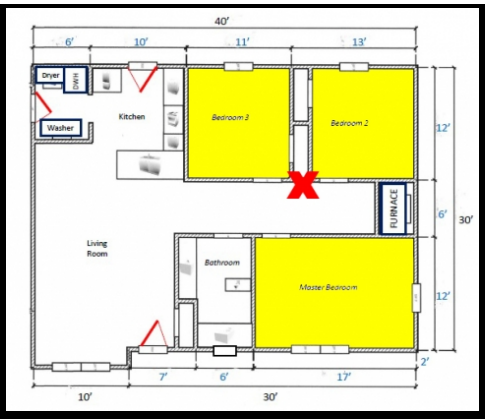
Specification(s):
Hardwired CO detection or warning equipment will be installed in accordance with the ASHRAE 62.2 or as required by the authority having jurisdiction

Installation will be accomplished by a licensed electrician when required by the authority having jurisdiction

Objective(s):
Ensure proper installation

Best Practice

All homes should have a carbon monoxide detector installed, whether hardwired or battery operated



Best Practice

Alarms should be mounted in sleeping areas - such as the one marked in red - as well as on each story of the home

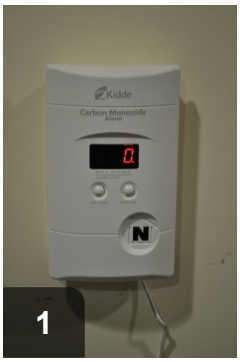
Tools:

1. Hammer

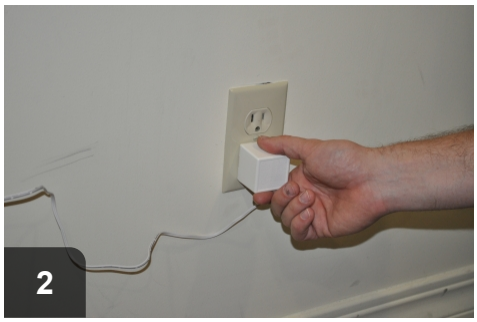
Materials:

1. Nails

Per WPN 17-7, full compliance with ASHRAE 62.2.2016 and NFPA 720 is required, which requires CO alarms on each story of the home, nearly any bedrooms that exist.



Mount alarm to wall close to bedrooms



Plug alarm into outlet. In addition, cord can be stapled into place

2.0301.2b - CO detection and warning equipment (battery operated)

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

Per WPN 17-7, full compliance with ASHRAE 62.2.2016 and NFPA 720 is required, which requires CO alarms on each story of the home, nearly any bedrooms that exist.

2.0403.4 - Pier and Skirting Foundations—Ground Moisture Barriers

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

2.0403.4a - Coverage

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.

Remove skirting as needed for access to crawlspace

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

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

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

Remove tools and excess material

Reinstall skirting

2.0403.4b - Material specification

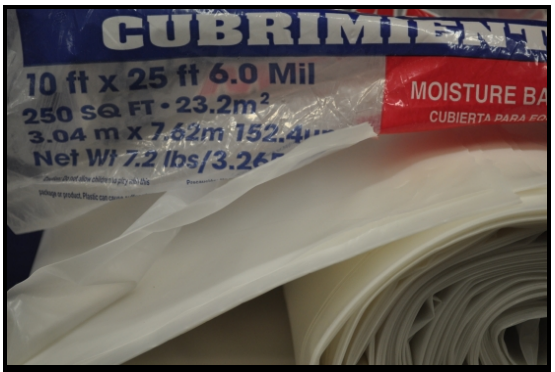
Desired Outcome:
Durable, effective ground moisture barrier that provides ongoing access and minimizes ground vapor

Specification(s):
A ground moisture barrier with a rating of no more than 0.1 perm 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 and able to withstand puncture

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. For vapor retarders in basements and crawl spaces, SWS calls for materials with a perm rating of ≤0.1 (which translates to 4mil or thicker). From 2007 IRC definition of vapor retarders: Class I: ≤ 0.1 perm (called impermeable), Class II: 0.1 to 1.0 perm (called semi-impermeable), Class III: 1.0 perm to 10 perms (called semi-permeable).

2.0403.4c - Overlap seams

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 6 mil)
3. Ballast
4. Furring strips
5. Moisture-resistant adhesive tape

Two different colors of poly used to highlight different layers

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

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

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

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

2.0403.4d - Fastening

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

Best Practice

Taping seams with waterproof adhesive tape can prevent barrier from moving

Best Practice

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

2.0404.2 - Crawl Spaces—Preliminary Dehumidification

Desired Outcome:
A dry and moisture controlled space ensured

2.0404.2a - Close vents

Desired Outcome:
A dry and moisture controlled space ensured

Specification(s):
Vents and other openings will be closed after ensuring sufficient combustion air for fuel burning appliances in accordance with IRC

Objective(s):
Reduce moisture load coming from outside of the crawl space

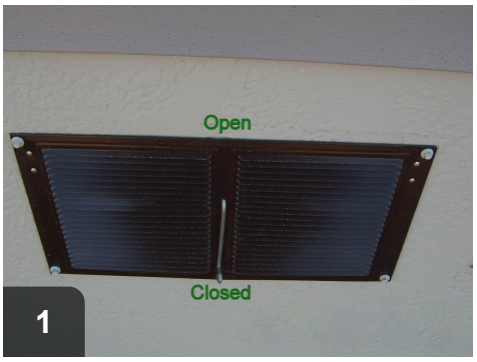
Before

Verify that adequate combustion air is available before closing vents

Best Practice

Closed manufactured home foundation vent

NOTE: This specification applies to masonry foundations built under the perimeter of the home. Such foundations are not commonly used with manufactured homes. IRC 2407 requires 50 cubic feet of volume in spaces where combustion appliances are located for every 1,000 Btuh of input. Ensure this requirement is met before closing off crawlspace vents.



Close vents to reduce moisture load from outdoor air

2.0404.2b - Drying

Desired Outcome:
A dry and moisture controlled space ensured

Specification(s):
If liquid moisture is present, the area will be dried until any liquid moisture is eliminated

Objective(s):
Reduce moisture in the crawl space

Improve work environment

Eliminate water in crawlspace before work

Dry crawlspace

Tools:

1. Wet/dry vacuum
2. Fan

Materials:

1. Mops
2. Towels

2.0404.2c - Drying time

Desired Outcome:
A dry and moisture controlled space ensured

Specification(s):
Space will be dehumidified until wood moisture content in solid, untreated lumber is less than 20%

Objective(s):
Reduce moisture content of wood

After correcting drainage and bulk moisture issues, use portable dehumidifiers to dry the space

After

Space has been dehumidified until moisture content in untreated lumber is less than 20%

Tools:

1. Moisture meter
2. Dehumidifier

2.0501.2 - Pier and Skirting Foundation—Venting

Desired Outcome:
Pollutants are effectively vented

2.0501.2a - Venting

Desired Outcome:
Pollutants are effectively vented

Specification(s):
Pier and skirting foundations will be vented in accordance with local climate conditions or code as required

Objective(s):
Provide ventilation for pollutant sources (e.g., moisture, radon, soil gases)

Use ventilated skirting as required by local code

Tools:

1. Snips
2. Circular saw with fine-toothed paneling or vinyl siding blade (reversing the blade may help reduce chipping)
3. Mallet
4. Screw gun

Materials:

1. Skirting panels
2. Top rails, front and back
3. Ground channels and 7-inch spikes
4. Screw

2.0501.2b - Occupant education

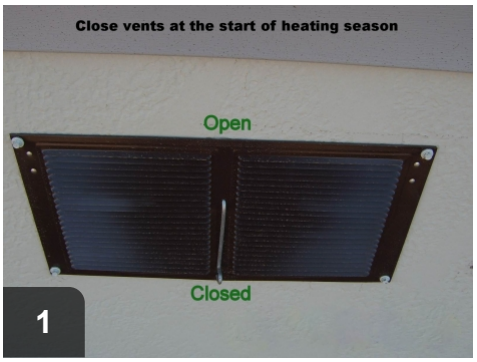
Desired Outcome:
Pollutants are effectively vented

Specification(s):
Occupants will be educated on purpose, operation, and maintenance of vents

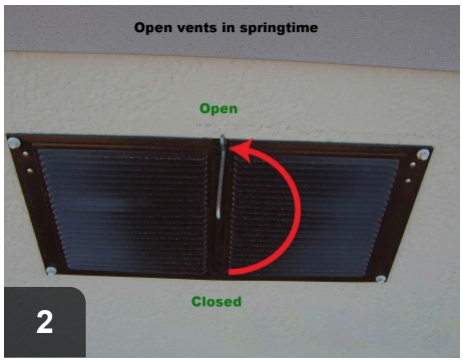
Objective(s):
Ensure vents function as intended

Teach homeowners how and when to operate foundation vents

Instruct homeowners that vents are intended to provide a path to outdoors for pollutants and soil moisture. Ideal settings for vents may be climate-dependents, but typically vents may be closed throughout the fall and winter when the air is relatively dry to conserve heat. They can be reopened when warmer weather begins in spring.



Close vents in fall or winter when heating season starts



Open foundation vents in spring time when weather warms

2.0602.1 - Static Electric Shock

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

2.0602.1a - Rigid fill tube

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:

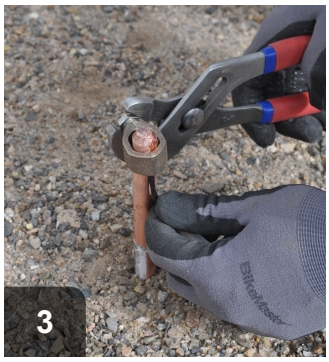
1. Wrench

Materials:

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

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 - Metal coupler grounding

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

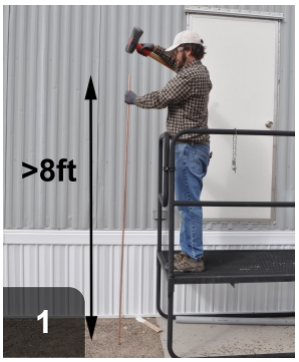
Fill tubes should be grounded to prevent electric shock to workers

Tools:

1. Sledgehammer
2. Wrench

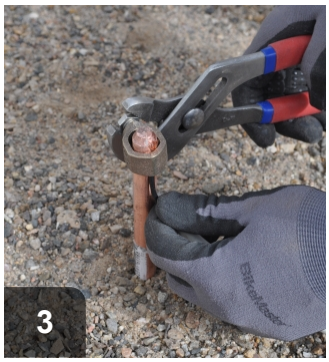
Materials:

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



Copper grounding rod should be at least 8' long

Grounding rod should be driven into the ground so that nearly all of rod is underground



Attach grounding wire to rod with coupler

Attach grounding wire to fill tube

Blow in insulation with peace of mind

that workers will not be electrocuted

2.0602.2 - House Current Electric Hazard

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

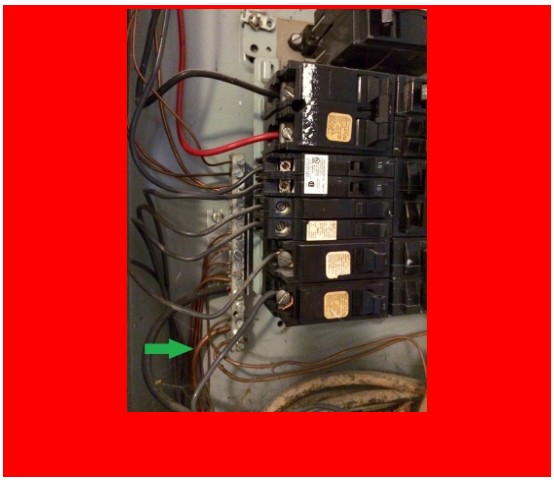
Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

2.0602.2a - Metal skin and frame grounding

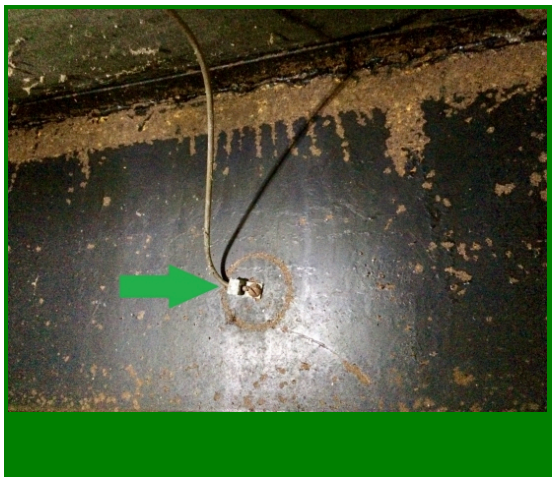
Desired Outcome:
Prevention of injury to the installer and occupant, and prevent damage to the structure, if required by authority having jurisdiction

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 - Metal fill tube grounding

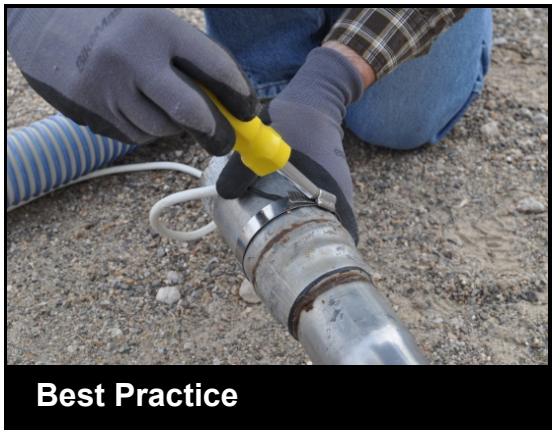
Desired Outcome:
Prevention of injury to the installer and occupant, and prevent damage to the structure, if required by authority having jurisdiction

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



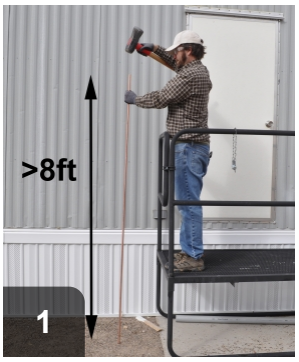
Attach grounding wire to metal of fill tube, not to flexible tubing

Tools:

1. Sledgehammer
2. Wrench

Materials:

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



A copper grounding rod should be submerged at least 8 feet underground

Attach grounding wire to grounding rod with acorn coupler

Attach grounding wire to metal fill tube with metal coupler

Proceed with blowing insulation without fear of static shock

2.0602.2c - Electrical tool safety

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

Inspect house for unsafe electrical situations

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

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 - Aluminum wiring

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.

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

3.1001.4 - General Penetrations (Electrical, HVAC, Plumbing, Vent Termination, Recessed Lighting)

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

Note:

3.1001.4a - Work assessment

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

Specification(s):
Installer prework assessment will be conducted to determine:

- Structural integrity
- Roof leaks
- Insect infestation
- Accessibility
- Number, type, size, and location of penetrations

Objective(s):
Ensure work space is safe and ready for air sealing

Verify scope of work

3.1001.4b - Air sealing penetrations

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)

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 - Sealant selection

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:

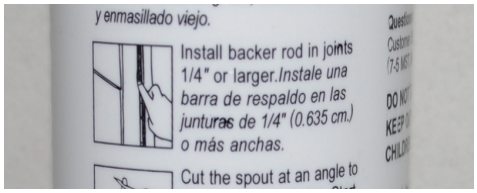
1. Caulk gun
2. Spray foam gun

Materials:

1. Caulk
2. Spray foam

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 - Ceiling hole repair

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

Hole in drywall ceiling

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.

Replace any missing insulation and repair holes in vapor barrier

Prepare the hole by cutting the edges clean and square

Cut drywall and fasten in place

Add joint tape and first coat of joint compound

3.1001.4e - Materials

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 - High temperature application

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

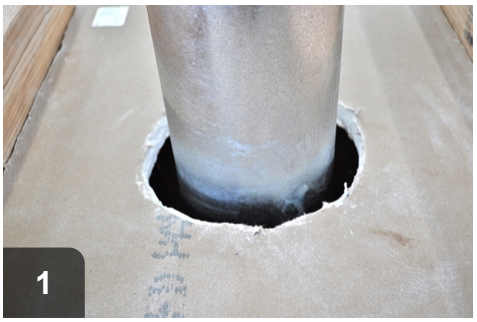
Sealed penetrations and chases should utilize high-temperature materials

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



1

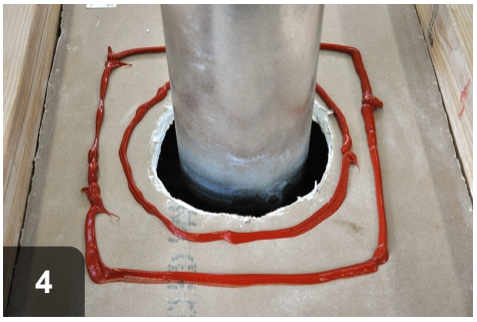
Prepare work area by removing any insulation and debris

2

Use high-temperature caulking (600F min)

3

Apply first ring of caulking to match shape of opening



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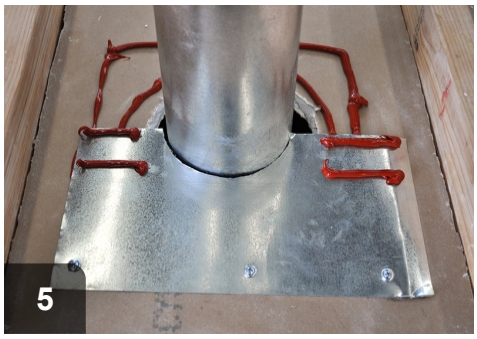

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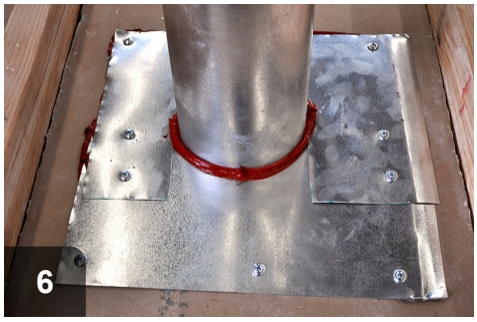


6

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

Fasten rigid material and apply additional caulking

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

3.1101.1 - Exterior Holes and Penetrations

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

3.1101.1a - Work assessment

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

Specification(s):
Installer prework assessment will be conducted to determine:

- Structural integrity
- Size of wall stud
- Insect infestation
- Accessibility
- Number, type, size, and location of penetrations

Objective(s):
Ensure work space is safe and ready for air sealing

Verify scope of work

3.1101.1b - Materials

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

Hole in exterior wall of manufactured home aluminum siding

Completed wall patch

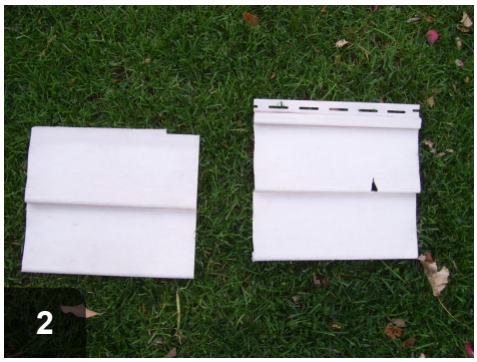
Tools:

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

Replace damaged siding



Use siding that matches the existing material's contour, texture, and color

3.1101.1c - Exterior wall air sealing

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 holes and penetrations on exterior surface of exterior walls will be sealed to ensure resistance to outdoor elements

Intentionally ventilated walls will not be sealed at vent locations (e.g., weep holes)

All holes and penetrations on the interior surface of exterior walls will be repaired

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 load

Ensure sealant is effective and durable

Before

Exterior penetrations need to be sealed with appropriate materials ensuring an air tight, weather tight seal.

After

Exterior penetrations have been sealed with appropriate materials ensuring an air tight, weather tight seal.

Tools:

1. caulk gun

Materials:

1. weatherproof caulk

Seams on aluminum siding must be tight.

Through the wall exhaust fan sealing.

Do not seal intentionally ventilated wall assemblies!

Backing or infill substrate may be needed for some wall patches.

Exterior electrical outlet sealing.

3.1101.2 - Interior Holes and Penetrations

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

3.1101.2a - Work assessment

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

Specification(s):
Installer prework assessment will be conducted to determine:

- Structural integrity
- Size of wall stud
- Insect infestation
- Accessibility
- Number, type, size, and location of penetrations

Objective(s):
Ensure work space is safe and ready for air sealing

Verify scope of work

3.1101.2b - Interior wall air sealing

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

Locate and expose penetrations to prepare for sealant

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

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

3.1101.2c - Materials

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

3.1101.3 - Holes, Penetrations, and Marriage Line

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

3.1101.3a - Work assessment

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

Specification(s):
Installer prework assessment will be conducted to determine:

- Structural integrity
- Insect infestation
- Accessibility
- Number, type, size, and location of penetrations
- Identify marriage walls and lines

Objective(s):
Ensure work space is safe and ready for air sealing

Verify scope of work

3.1101.3b - Marriage wall air sealing of holes and penetrations

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

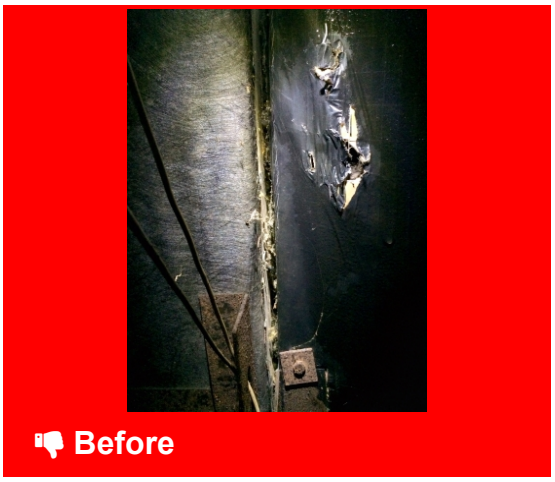
Objective(s):

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

Clean belly wrap before air sealing

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

Apply foam or caulking over backer

3.1101.3c - Marriage line air sealing

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

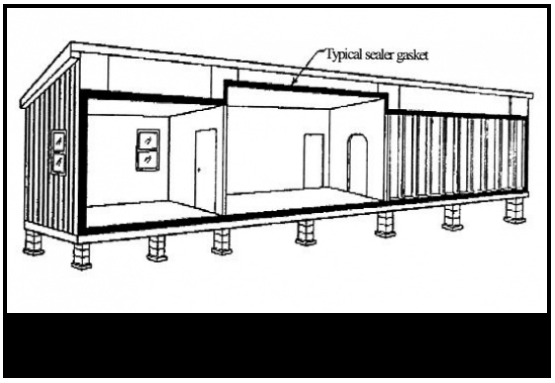
Backing or infill will be provided at the marriage line as needed

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.

Identify leaks in marriage line using a blower door and smoke

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

3.1101.3d - Materials

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

Specification(s):
Materials will be used or installed in accordance with product manufacturer specifications

Objective(s):
Select materials to ensure durable and permanent repair

Hole in exterior wall of manufactured home aluminum siding

Completed wall patch

Tools:

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

Materials:

1. Aluminum siding or flashing
2. Caulk (formulated for exterior use)
3. Corrosion-resistant fasteners

3.1201.5 - Manufactured Housing Windows and Doors

Desired Outcome:
Windows and doors are operable, sealed, and weathertight

Note:

3.1201.5a - Work assessment

Desired Outcome:
Windows and doors are operable, sealed, and weathertight

Specification(s):
Installer prework assessment will be conducted to determine:

- Number
- Type
- Operating condition
- Wall construction

Objective(s):
Ensure work space is safe and ready for air sealing

Verify scope of work

3.1201.5b - Lead paint assessment

Desired Outcome:
Windows and doors are operable, sealed, and weathertight

Specification(s):
Presence of lead-based paint in pre-1978 homes will be assumed unless testing confirms otherwise; documentation of testing results will be kept on file

EPA's Renovation, Repair and Painting (RRP) Program Rule (40 CFR Part 745) in pre-1978 homes and proposed changes to this rule (Federal Register/Vol. 75, No. 87/May 6, 2010) will be complied with, to be superseded by any subsequent final rulemaking or any more stringent state or federal standards

Objective(s):

Protect worker and occupant from potential lead hazards

Best Practice

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.

Clean tools and sample site to prevent contamination

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

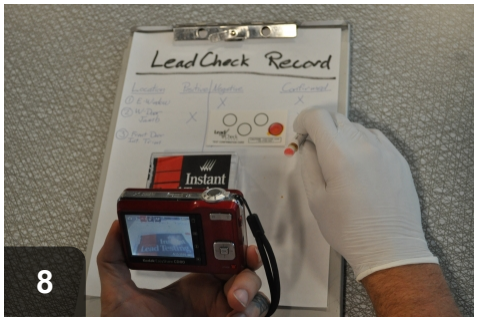
Break capsules and shake to mix reagents. Swab sample site for 30 seconds

Check swab for reaction

Red indicates lead positive. White is lead negative

If negative, verify validity of test with provided calibration card

Lead in calibration card should test positive and turn red



Record test results to maintain documentation

3.1201.5c - Operable windows and doors

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.

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.

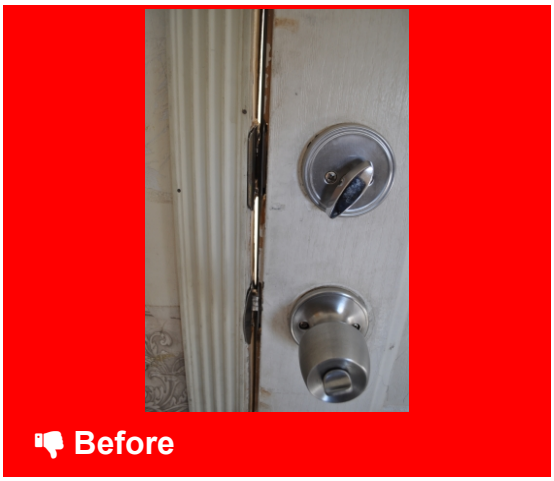
Manufactured housing should have two egress doors located away from one another. Stairs or ramps may be needed outside.

3.1201.5d - Air infiltration

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

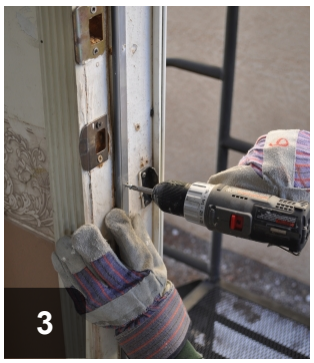
After weatherstripping and adjustment of door in jamb, air infiltration is eliminated

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



Door jamb is missing any weatherstripping

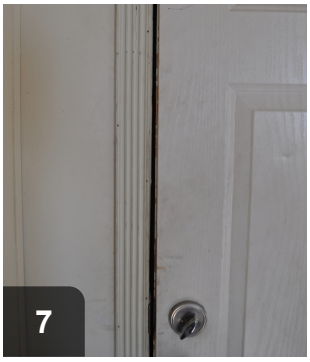
Measure door jamb for weatherstripping

Install new weatherstrip

Measure bottom of door for door sweep

Install new door sweep

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



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

3.1201.5e - Water infiltration

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 - Materials

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

3.1201.5g - Quality assurance

Desired Outcome:
Windows and doors are operable, sealed, and weathertight

Specification(s):
Windows and doors will be adjusted to properly fit the jamb and allow for ease of operation and security

Objective(s):
Ensure proper operation of the window, door, and hardware

Ensure air and watertight installation

3.1201.5h - Occupant education and maintenance

Desired Outcome:
Windows and doors are operable, sealed, and weathertight

Specification(s):
Occupants will be notified of changes or repairs made and will be educated on how to operate and maintain windows and doors

Objective(s):
Ensure long-term weathertightness

3.1201.6 - Interior Storm Windows

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

Note:

3.1201.6a - Work assessment

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

Specification(s):
Installer prework assessment will be conducted to determine:

- Number
- Type
- Size
- Condition of opening

Objective(s):
Verify scope of work

3.1201.6b - Fixed storm window

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

Unsafe

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

Safe

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 - Installing operable storm window

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

Before

No interior storm window has been installed.

After

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

Tools:

1. drill

Materials:

1. mechanical fastners
2. weatherstripping

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

Storm window has been installed according to manufacturers

compress the desired sealant. specifications and operates smoothly.

3.1201.6d - Health and safety

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

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

3.1201.6e - Occupant education

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

Specification(s):
Occupants will be educated on the proper use and maintenance of storm windows

Objective(s):

Ensure weathertightness and safety

3.1202.3 - Replacing Damaged Window Glass in Manufactured Housing

Desired Outcome:
Glass complete and intact

Note:

3.1202.3a - Work assessment

Desired Outcome:
Glass complete and intact

Specification(s):
Installer prework assessment will be conducted to determine:

- Number
- Type
- Location
- Operating condition
- Wall construction
- Size

Objective(s):
Ensure that work space is safe and ready for glass replacement

Verify scope of work

3.1202.3b - Lead paint assessment

Desired Outcome:
Glass complete and intact

Specification(s):
Presence of lead-based paint in pre-1978 homes will be assumed unless testing confirms otherwise; documentation of testing results will be kept on file

EPA's Renovation, Repair and Painting (RRP) Program Rule (40 CFR Part 745) in pre-1978 homes and proposed changes to this rule (Federal Register/Vol. 75, No. 87/May 6, 2010) will be complied

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

Objective(s):
Protect worker and occupant from potential lead hazards

Best Practice

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.

Clean tools and sample site to prevent contamination

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

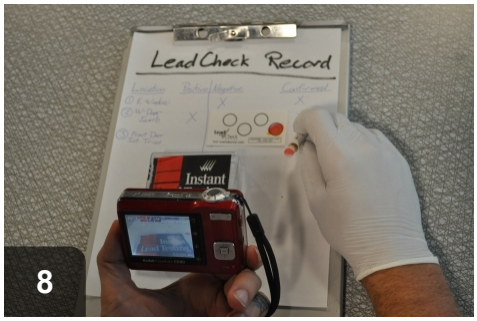
Break capsules and shake to mix reagents. Swab sample site for 30 seconds

Check swab for reaction

Red indicates lead positive. White is lead negative

If negative, verify validity of test with provided calibration card

Lead in calibration card should test positive and turn red



Record test results to maintain documentation

3.1202.3c - Broken glass removal

Desired Outcome:
Glass complete and intact

Specification(s):
Damaged glass will be removed

Objective(s):
Safely remove old glass

Before

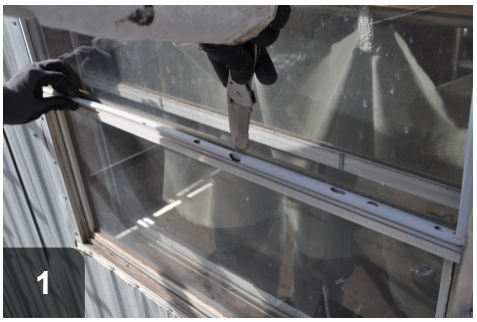
Broken or cracked window glass should be replaced to minimize air leakage

In Progress

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

Tools:

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



Remove exterior stops--these will probably not be salvagable

Wearing protective gloves, remove large glass pieces carefully

Sweep up all remaining small glass slivers

Sash should be completely clear of

debris before moving forward with installation

3.1202.3d - Opening preparation

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

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 - New glass installation

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

In Progress

Sash should be completely clear debris before installing new glass

After

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

Tools:

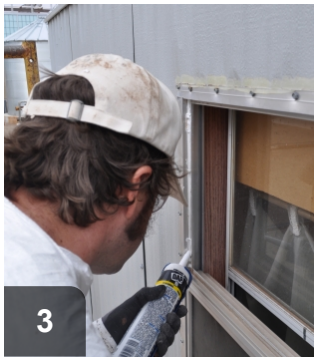
1. Caulk gun
2. Tape measure

Materials:

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

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

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



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

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

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

Apply glazing or install replacement stops to seal window from exterior

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

3.1203.3 - Replacement of Manufactured Housing Windows and Doors

Desired Outcome:
Smooth operation and an airtight and weathertight fit of replacement windows and doors

Note:

3.1203.3a - Work assessment

Desired Outcome:
Smooth operation and an airtight and weathertight fit of replacement windows and doors

Specification(s):
Installer prework assessment will be conducted to determine:

- Number
- Type
- Operating condition
- Wall construction

Objective(s):
Ensure work space is safe and ready for air sealing

Verify scope of work

3.1203.3b - Lead paint assessment

Desired Outcome:
Smooth operation and an airtight and weathertight fit of replacement windows and doors

Specification(s):
Presence of lead-based paint in pre-1978 homes will be assumed unless testing confirms otherwise; documentation of testing results will be kept on file

EPA's Renovation, Repair and Painting (RRP) Program Rule (40 CFR Part 745) in pre-1978 homes and proposed changes to this rule (Federal Register/Vol. 75, No. 87/May 6, 2010) will be complied with, to be superseded by any subsequent final rulemaking or any more stringent state or federal standards

Objective(s):

Protect worker and occupant from potential lead hazards

Best Practice

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.

Clean tools and sample site to prevent contamination

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

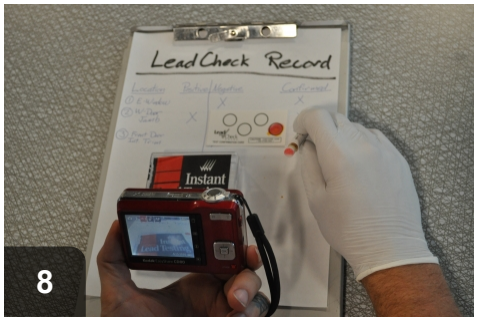
Break capsules and shake to mix reagents. Swab sample site for 30 seconds

Check swab for reaction

Red indicates lead positive. White is lead negative

If negative, verify validity of test with provided calibration card

Lead in calibration card should test positive and turn red



Record test results to maintain documentation

3.1203.3c - Window or door selection

Desired Outcome:
Smooth operation and an airtight and weathertight fit of replacement windows and doors

Specification(s):
Window or door units will be designed for manufactured home use and will be ENERGY STAR qualified

Rough opening will be measured before ordering replacements

Access to emergency egress points, such as primary windows or exit doors, will be considered during the selection of retrofit window or door units

Objective(s):
Ensure proper size, type, and operation of window or door

3.1203.3d - Rough opening preparation

Desired Outcome:
Smooth operation and an airtight and weathertight fit of replacement windows and doors

Specification(s):
Existing units will be removed

Opening will be cleaned

Any damaged framing will be replaced

Opening for installation will be prepared in accordance with manufacturer specifications

Objective(s):
Provide a clean opening for replacement unit

3.1203.3e - Window and door installation

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.

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 - Safety

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

3.1203.3g - Maintenance and occupant education

Desired Outcome:
Smooth operation and an airtight and weathertight fit of replacement windows and doors

Specification(s):
Occupants will be notified of changes or repairs made and will be educated on how to operate and maintain window or door

Objective(s):
Ensure long-term weathertightness

3.1301.1 - Electrical, HVAC, Plumbing, Gas, Dryer Vent, and General Penetrations Through Bottom Board

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

Note:

3.1301.1a - Work assessment

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

Specification(s):
Installer prework assessment will be conducted to determine:

- Structural integrity
- Standing water
- Raw sewage
- Insect infestation
- Pests
- Accessibility
- Number, type, size, and location of penetrations

Objective(s):
Ensure work space is safe and ready for air sealing

Verify scope of work

3.1301.1b - Soft bottom board repair

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

Specification(s):
Patching material will be provided as needed to meet the specific characteristics of the bottom

board material and the characteristics of the hole

Patch will have a service life of a minimum of 20 years

Objective(s):
Minimize air leakage

Keep insulation in place

Ensure repair materials are compatible

Ensure patch will support insulation

3.1301.1c - Hard bottom board repair

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

Specification(s):
Patching will be provided as needed to meet both the specific characteristics of the bottom board material and the characteristics of the hole

Patch will not bend, sag, or move once installed

Patch will be permanent

Objective(s):
Minimize air leakage

Ensure repair materials are compatible

Minimize hole size to ensure successful use of sealant

Ensure closure is permanent and supports insulation

Ensure sealant does not fall out

3.1301.1d - Bottom board penetrations

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

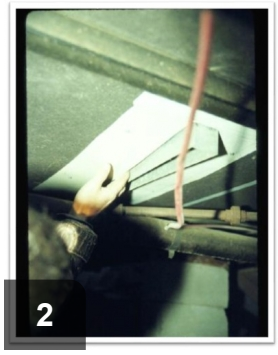
Tools:

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

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)

3.1301.1e - Materials

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

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

Surface preparation and material selected will be used or installed in accordance with product manufacturer specifications

Objective(s):
Select materials to ensure durable and permanent repair

3.1301.2 - Electrical, HVAC, Plumbing, Gas, Dryer Vent, and General Penetrations Through Flooring

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

3.1301.2a - Work assessment

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

Specification(s):
Installer prework assessment will be conducted to determine:

- Structural integrity
- Insect infestation
- Pests
- Accessibility
- Plumbing leaks
- Number, type, size, and location of penetrations

Objective(s):
Ensure work space is safe and ready for air sealing

Verify scope of work

3.1301.2b - Floor air sealing (decking, subfloor, floor decking)

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

Specification(s):
Backing or infill will be provided as needed to meet the specific characteristics of the selected sealant and the characteristics of the penetration

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

Objective(s):

Ensure resulting closure is permanent and supports expected load

Ensure sealant is effective and durable

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

Gaps should be sealed to maintain air barrier

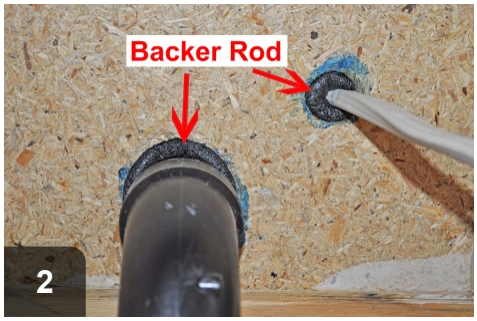
Tools:

1. Headlamp

Materials:

1. Backer rod
2. Sealant

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

3.1301.2c - Sealant selection

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

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, if required

Objective(s):
Ensure sealant meets or exceeds the performance characteristics of the surrounding materials

Avoid sealants that do not allow for expansion between dissimilar materials

Flexible sealants compensate for differential expansion and maintain a seal

Tools:

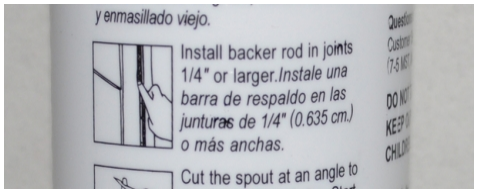
1. Caulk gun
2. Spray foam gun

Materials:

1. Caulk
2. Spray foam

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

3.1301.2d - Floor repair

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).

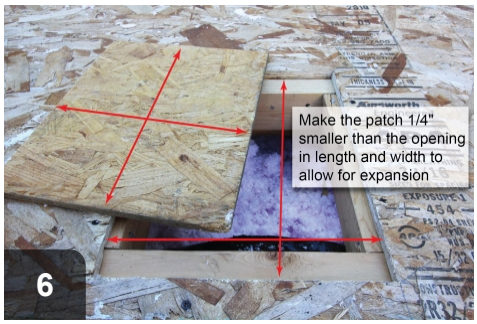
Carefully remove trim and floor coverings from area to be repaired

Mark the joist locations on either side of the damaged area

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

Cut four 2X4 blocks to support the patch

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



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

Apply subfloor adhesive to nailers

Fasten with 2" deck screws

3.1301.2e - Structural materials

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

After

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

3.1301.2f - High temperature application

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

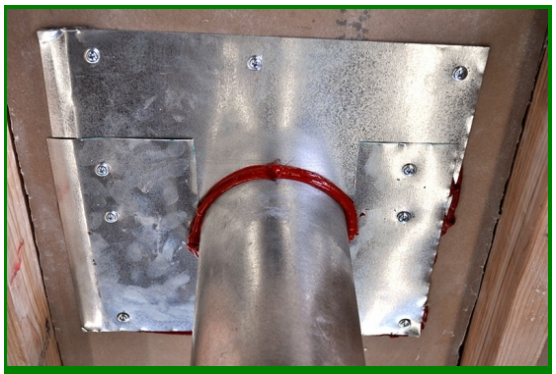
Specification(s):
Only noncombustible materials will be used in contact with chimneys, combustion exhaust vents, and flues

Objective(s):

Prevent a fire hazard

Before

Gaps around floor penetrations allow air and moisture movement



After

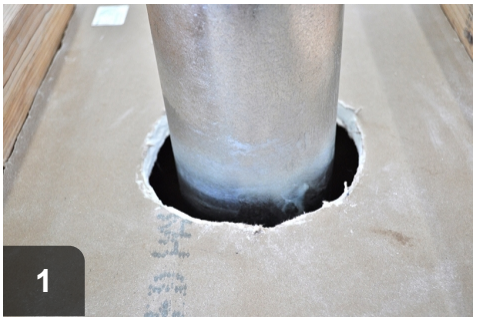
Use non-combustible materials, like 26-gauge steel and high-temp caulk

Tools:

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

Materials:

1. High-temperature caulk
2. Non-combustible material such as aluminum or galvanized steel flashing or cement board



1

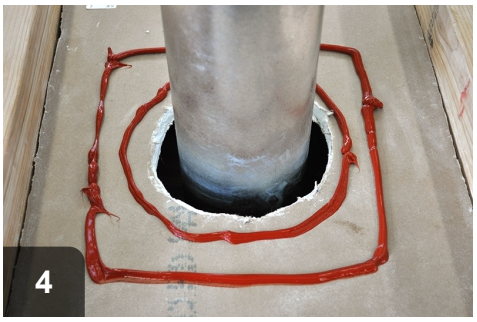
Prepare work area by removing any insulation and debris

2

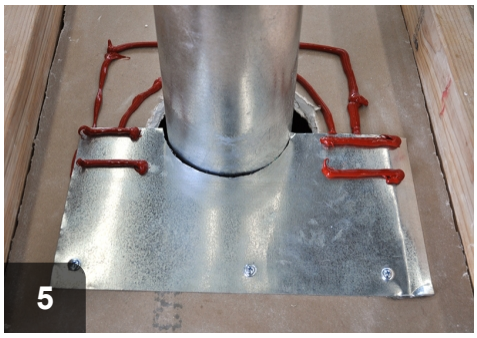
Use high-temperature caulking (600F min)

3

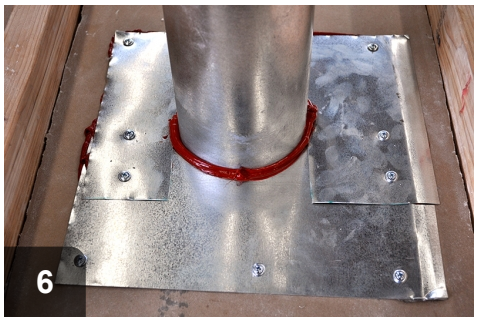
Apply first ring of caulking to match shape of opening



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



Fasten rigid material and apply additional caulking



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

3.1601.5 - Preparation and Mechanical Fastening

Desired Outcome:
Ducts and plenums properly fastened to prevent leakage

Note:

3.1601.5a - Preparation

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

When making connections at interior walls, mastic should be applied to boot and wall, and allowed to dry entirely

3.1601.5b - Metal to metal

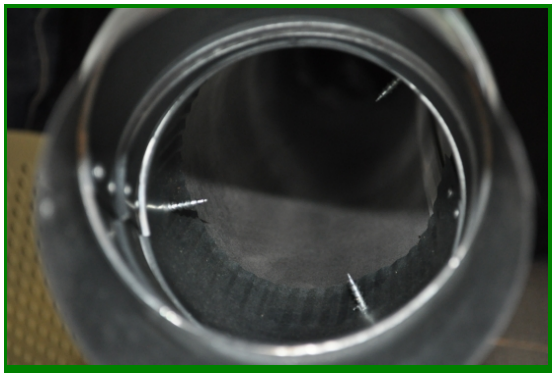
Desired Outcome:
Ducts and plenums properly fastened to prevent leakage

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:

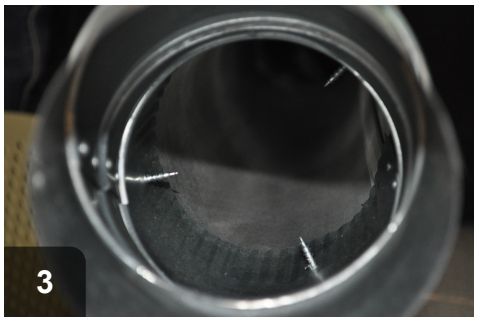
1. Drill

Materials:

1. Fasteners

Realign and join ducts to create a smooth transition

Use fasteners to hold duct together and prevent future dislocation



Attach ducts using a minimum of three, evenly-spaced fasteners

3.1601.5c - Flex to metal

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

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

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

Apply mastic to flange

Slide inner liner onto flange with sealant

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

Slide insulation and outer casing over metal ducting

Extend insulation and casing until in contact with other insulation

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

3.1601.5d - Duct board to duct board

Desired Outcome:
Ducts and plenums properly fastened to prevent leakage

Specification(s):
Joints will be fastened with outward clinching (stitch) staples and c-channels if possible

Objective(s):
Ensure durable joints

3.1601.5e - Duct board to flexible duct

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.

Gather materials

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

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

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

Slide flex duct liner over mastic-coated metal collar

Secure with properly tensioned zip tie.

Coat seam with mastic

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

3.1601.5f - Duct board plenum to air handler cabinet

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

Best Practice

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 - Boot to wood

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:

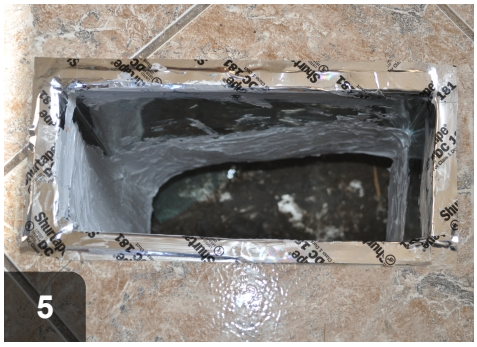
1. Metal screws
2. Ring-shank nails

Replace damaged ducting if necessary

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

Drill pilot holes for metal fasteners

Use metal fasteners to secure duct to subfloor



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

3.1601.5h - Boot to gypsum

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 accomodate 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

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)

3.1601.5i - Duct board to flex

Desired Outcome:
Ducts and plenums properly fastened to prevent leakage

Specification(s):
Metal take-off collar with a hip and an internal metal backer will be used

Take-offs will be in accordance code requirements

Objective(s):
Ensure durable joints

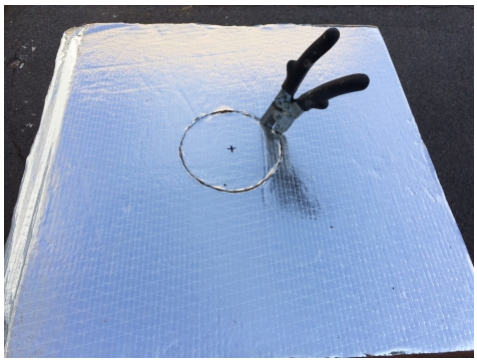
Bad Practice

Improper attachment of flex to duct board

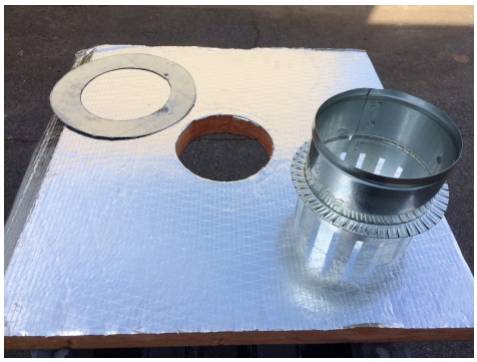
After

Flex duct correctly installed and sealed to duct board

Select a backer ring and flex duct installation tools



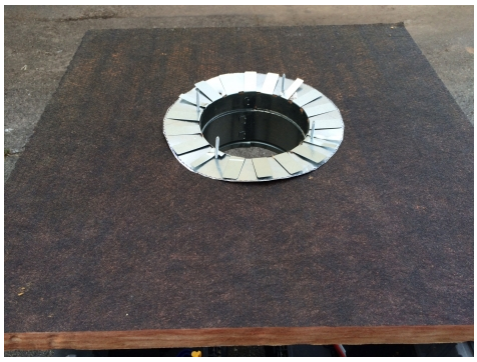
Cut the proper size hole in duct board



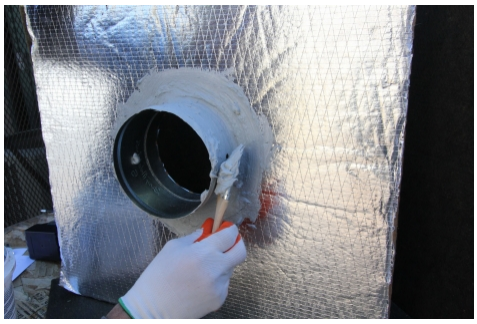
Select starting collar with tabs matching the thickness of the duct board

3.1601.5i - Duct board to flex

Insert the starting collar, bend tabs over and install at least 3 screws through the collar, duct board, and backer ring



Starting collar with tabs bent over and screws through the duct board and backer ring



Apply mastic liberally and install flex duct

3.1602.8 - Supply Plenum (Furnace to Trunk Duct Connection) in Both Upflow and Downflow Air Handler Configurations

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

Note:

3.1602.8a - Work assessment

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

Specification(s):
Installer prework assessment will be conducted to determine:

- Size of plenum
- Alignment
- Connection method
- Existing sealing

Objective(s):
Ensure an efficient and effective way to accomplish work

Verify scope of work

3.1602.8b - Preparation

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

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 - Plenum rebuild or repair

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

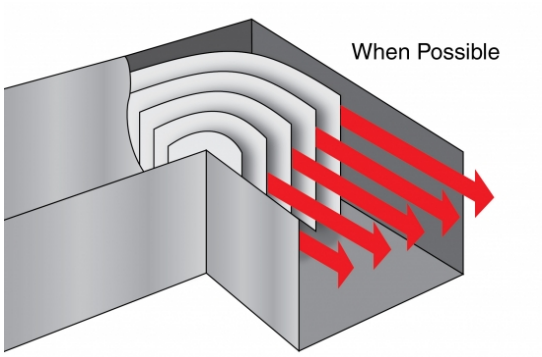
If possible, flow diverter or turning vanes will be installed for air flow and/or balancing (e.g., bullhead Ts, offset air handler)

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 - Repair work access

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

After

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.

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 - Safety testing

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

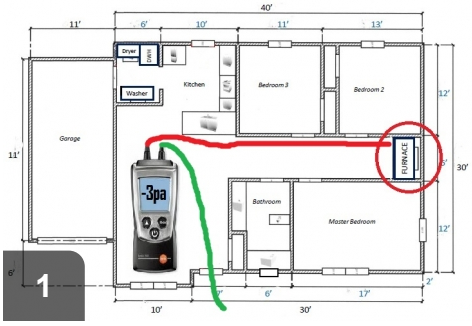
Objective(s):
Verify operation

Identify unsafe equipment operating conditions

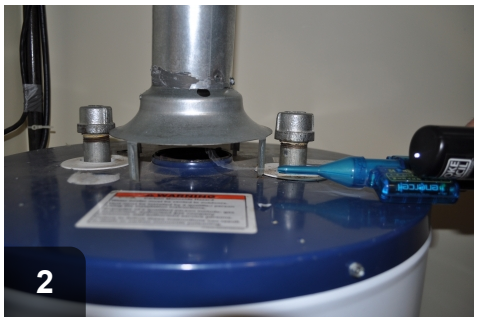
Conduct spillage and depressurization testing at the end of the work day

Tools:

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



Run depressurization test at the end of the work day



Complete spillage test using chemical smoke pencil or mirror

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

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

Check carbon monoxide levels on all combustion appliances

3.1602.8f - Performance testing

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

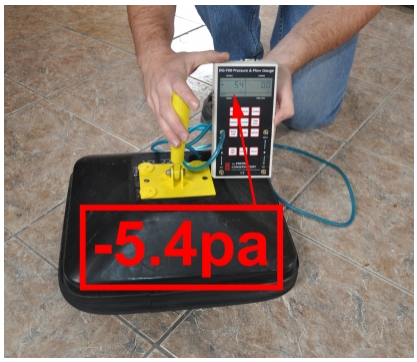
Materials:

1. Duct mask

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



Perform pressure pan test on

Perform pressure pan test after work is

pressure pan testing before and after work

ductwork before beginning work. Record result

completed and compare to 'before' reading

Record test results to determine improvement of performance

3.1602.9 - Crossover Ducts

Desired Outcome:
Deliver all air from trunk to trunk without leakage or restriction

Note:

3.1602.9a - Work assessment

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

In Progress

Locate the best access and egress points

In Progress

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

3.1602.9b - Flexible crossover duct connections

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

Unattached ducts are useless

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

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

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

Apply mastic at metal-to-metal connection

Apply mastic to all elbow joints and flange

Slide inner liner onto flange with sealant

Fasten inner inner with tie band using band tensioner

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

Secure insulation and outer casing place with tie band

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

3.1602.9c - Support

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

3.1602.9d - Through-the-rim crossover duct

Desired Outcome:

Deliver all air from trunk to trunk without leakage or restriction

Specification(s):
Through-the-rim crossover ducts will be located and accessed through the bottom liner and branch duct; all branch crossover duct connections and end caps will be located and accessed

Hole size (air pathway) will be maximized between branch crossover and trunk

All connections will be mechanically fastened and sealed inside duct

End caps will be sealed

Objective(s):
Ensure all connections are identified

Maximize air flow and distribution

Ensure lasting durable connections

Minimize air leakage

3.1602.9e - Repair work access for through-the-rim crossover

Desired Outcome:
Deliver all air from trunk to trunk without leakage or restriction

Specification(s):
Access hole in the trunk duct will be repaired and sealed

Insulation will be reinstalled

Bottom liner/belly will be repaired

Objective(s):
Repair work access

Minimize heat transfer

3.1602.9f - Attic crossover

Desired Outcome:

Deliver all air from trunk to trunk without leakage or restriction

Specification(s):
Access to the attic will be created for all attic areas that contain crossover ducts, where feasible

Plenum boxes and crossover duct connections will be rebuilt, mechanically fastened, and sealed

Access holes will be repaired

Objective(s):
Ensure lasting durable connections

Minimize air leakage

Maximize air flow and distribution

Repair work access

3.1602.9g - Combustion Appliance Zone (CAZ) testing

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

Best Practice

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.

3.1602.9h - Performance testing

Desired Outcome:
Deliver all air from trunk to trunk 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

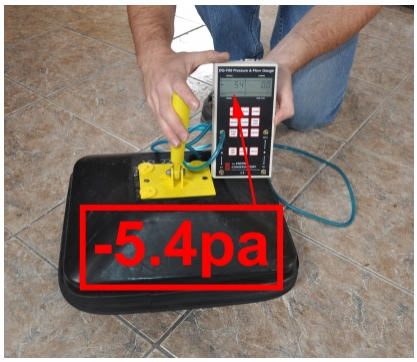
Materials:

1. Duct mask

Run duct blaster test before beginning work and record result

Run duct blaster test after work and compare with 'before' reading. Record result

Set-up blower door to perform pressure pan testing



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 readings before and after to determine if performance has improved

3.1602.10 - Hard and Flex Branch Ducts

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

Note:

3.1602.10a - Work assessment

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

Specification(s):
Installer prework assessment will be conducted to determine:

- Location
- Connection types
- Leakage points

Access holes will be created for the work done at each location

Objective(s):
Verify scope of work

Gain access to duct connections

3.1602.10b - Reduce excess flex duct length

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

Specification(s):
Excess flex duct will be removed between the takeoff at trunk and floor register boot

Objective(s):
Improve air flow

Before

This duct is far too long, resulting in poor airflow.

After

The duct has been shortened, and is now properly supported.

3.1602.10c - Duct connection repairs

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

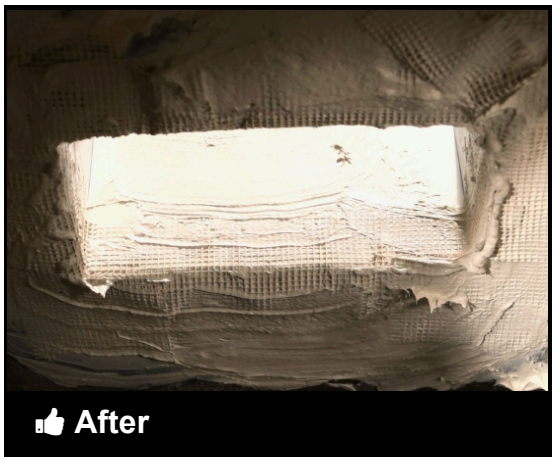
Ends will be sealed

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

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 - Repair work access

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

Access hole cut into manufactured home branch duct

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:

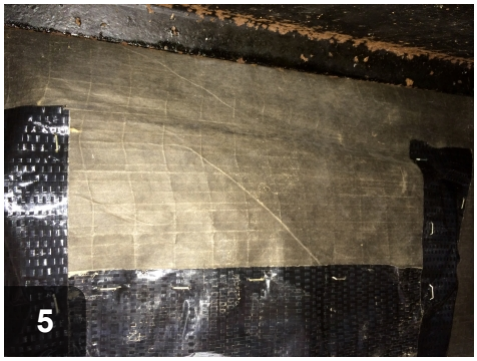
1. Fiberglass mesh tape
2. Mastic duct sealant
3. Foil tape
4. Insulation
5. Belly repair tape
6. Belly wrap
7. Staples
8. Solvent (acetone, paint thinner, denatured alcohol, Goof-Off, or similar) to clean aluminum duct
9. Spray adhesive for belly repairs

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

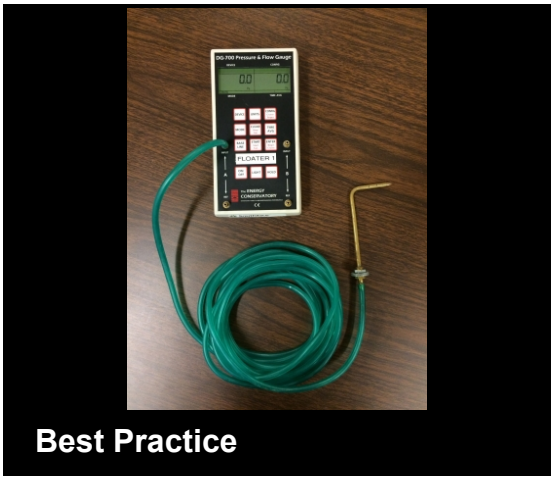
3.1602.10e - Combustion Appliance Zone (CAZ) testing

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

See SWS 2.0201.3a-2.0201.3h for CAZ testing

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.

3.1602.10f - Performance testing

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

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

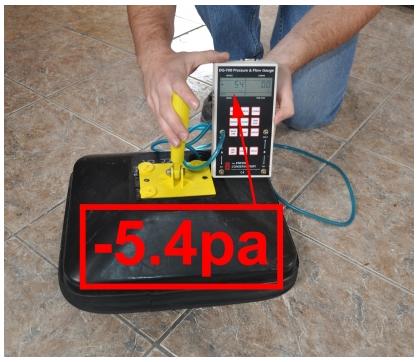
Materials:

1. Duct mask

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

3.1602.11 - Air Sealing System

Desired Outcome:
Ducts and plenums sealed to prevent leakage

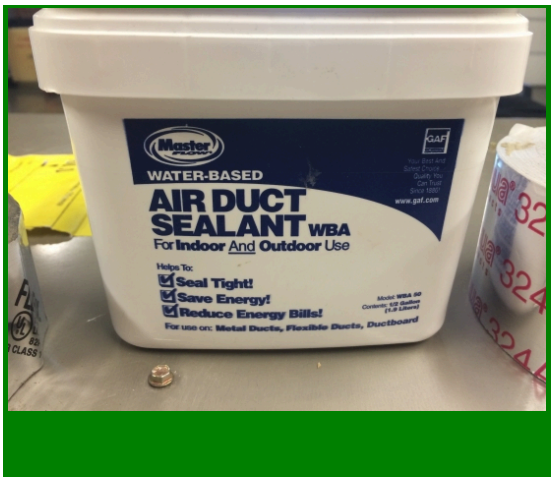
Note:

3.1602.11a - New component to new component sealant selection

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

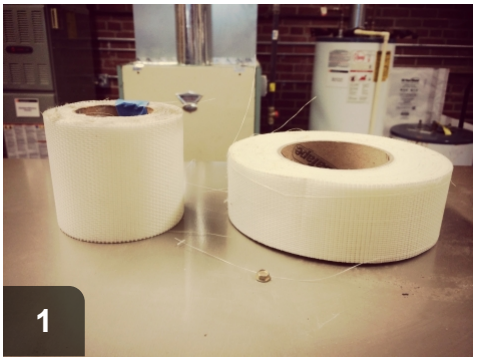
Materials:

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
4. Spray polyurethane foam

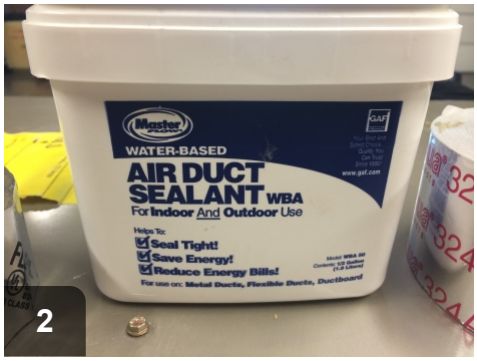
Per the 2012 IRC, use tape labeled 181 B-FX and/or mastic labeled 181 BM. Seal and mechanically fasten all duct connections to metal flanges. Fasten round metal ducts with at least three screws equally spaced around the diameter, and make sure that the ducts and fittings are inserted at least 1". DO NOT USE unlisted duct tape as a sealant on any duct.

Exceptions:

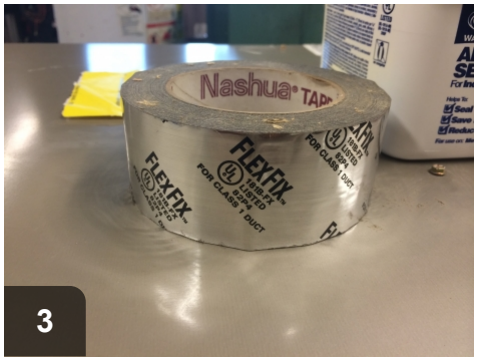
1. Spray polyurethane foam shall be permitted to be applied without additional joint seals.
2. Where a duct connection is made that is partially inaccessible, three screws or rivets shall be equally spaced on the exposed portion of the joint so as to prevent a hinge effect.
3. Continuously welded and 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. "



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 - New component to existing component

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

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

Apply mastic to metal collar

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

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

3.1602.11c - Existing component to existing component

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 ¾" will be repaired using rigid duct material

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

Fiberglass mesh and mastic will be the primary seal

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

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

Sealed ductwork connections help prevent leakage

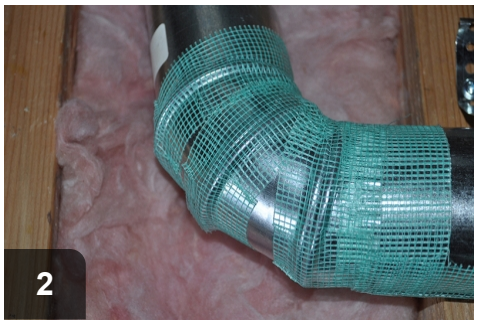
Tools:

1. Brush

Materials:

1. Mastic
2. Fiberglass mesh tape

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



Wrap joint with fiberglass mesh tape

Apply UL 181 mastic to seal joint

3.1602.11d - Performance testing

Desired Outcome:
Ducts and plenums sealed to prevent leakage

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 performed

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

Record readings before and after to determine improvement in performance

Tools:

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

Materials:

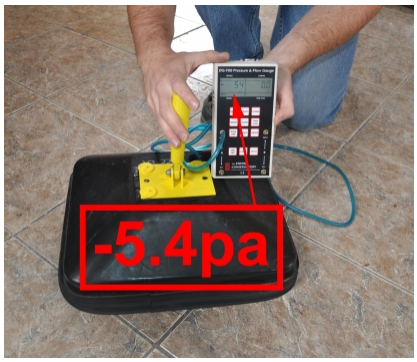
1. Duct mask

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



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

3.1602.12 - Air Sealing System Components

Desired Outcome:
Ducts and plenums sealed to prevent leakage

Note:

3.1602.12a - Duct boot to interior surface

Desired Outcome:
Ducts and plenums sealed to prevent leakage

Specification(s):
Gaps between boot and gypsum less than a ¼" will be sealed using mastic or appropriate flexible caulking

Gypsum edge will be wetted before applying mastic

Objective(s):
Prevent air leakage

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

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

Tools:

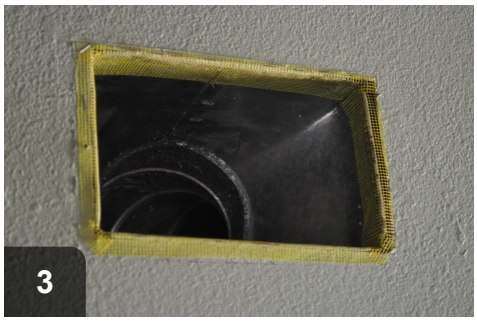
1. Utility knife
2. Spray bottle
3. Putty knife

Materials:

1. Mastic
2. Fiberglass mesh tape

Remove grill to expose duct boot and gaps

Wet the edges of the drywall to ensure a good bond



Cut mesh tape to fit around duct boot and cover gaps

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

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

3.1602.12b - Air handler cabinet outside conditioned space

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)

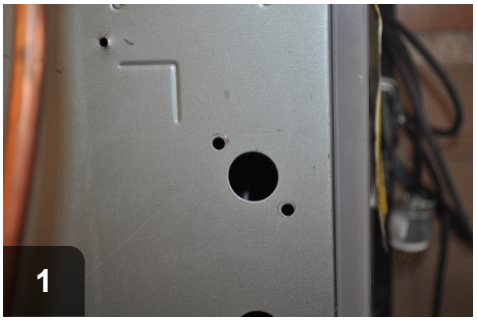
Objective(s):
Reduce air leakage while maintaining accessibility

Unnecessary holes in the air handler cabinet need to be sealed

Use removable foil tape to seal holes

Materials:

1. Foil tape



Unnecessary holes in the air handler cabinet should be sealed

Removable foil tape should be used to seal

Fully cover holes with tape to seal completely

3.1602.12c - Performance testing

Desired Outcome:
Ducts and plenums sealed to prevent leakage

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

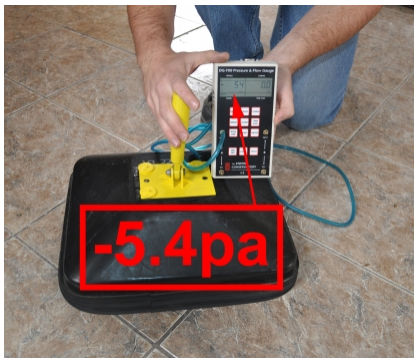
Materials:

1. Duct mask

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



Perform pressure pan test on

Perform pressure pan test after work is

pressure pan testing before and after work

ductwork before beginning work. Record result

completed and compare to 'before' reading

Record test results to determine improvement of performance

3.1602.13 - Return—Framed Platform

Desired Outcome:
The return duct is installed to prevent air leakage

Note:

3.1602.13a - Preparation

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 - Infill and backing

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, such as drywall

Tools:

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

Materials:

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

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

3.1602.13c - Sealant selection

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

Paraphrased from 2012 IRC R302.9: Wall and ceiling finishes will have a flame spread index of 200 or less and a smoke-developed index of 450 or less

3.1701.1 - Holes, Penetrations, and Connection Seam

Desired Outcome:
The exterior of the seam is weathertight and connection between house and addition is properly sealed to minimize air leakage and moisture movement between unconditioned and conditioned space

3.1701.1a - Work assessment

Desired Outcome:
The exterior of the seam is weathertight and connection between house and addition is properly sealed to minimize air leakage and moisture movement between unconditioned and conditioned space

Specification(s):
Installer prework assessment will be conducted to determine:

- Structural integrity
- Roof leaks
- Insect infestation
- Accessibility
- Mechanical attachment
- Location of marriage wall seams
- Number, type, size, and location of penetrations

Objective(s):
Ensure work space is safe and ready for air sealing

Verify scope of work

3.1701.1b - Hole, seam, line, and penetration sealing

Desired Outcome:
The exterior of the seam is weathertight and connection between house and addition is properly sealed to minimize air leakage and moisture movement between unconditioned and conditioned space

Specification(s):

Marriage wall seams will be sealed continuously at walls, floors, and ceiling connection

All accessible holes and penetrations in the addition envelope will be sealed

Backing or infill will be provided as needed, when accessible

Objective(s):
Minimize air leakage

Maintain durability and/or flexibility

Ensure sealant is effective and durable

3.1701.1c - Materials

Desired Outcome:
The exterior of the seam is weathertight and connection between house and addition is properly sealed to minimize 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

3.1701.1d - Addition exterior wall air sealing

Desired Outcome:
The exterior of the seam is weathertight and connection between house and addition is properly sealed to minimize air leakage and moisture movement between unconditioned and conditioned space

Specification(s):
All holes and penetrations on exterior surface of exterior walls will be sealed to ensure resistance to outdoor elements

Intentionally ventilated walls will not be sealed at vent locations (e.g., weep holes)

All holes and penetrations on the interior surface of exterior walls will be repaired

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

3.1701.1e - Addition interior wall air sealing

Desired Outcome:
The exterior of the seam is weathertight and connection between house and addition is properly sealed to minimize air leakage and moisture movement between unconditioned and conditioned space

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 load

Ensure sealant is effective and durable

3.1701.1f - Addition floor air sealing (decking, subfloor, floor decking)

Desired Outcome:
The exterior of the seam is weathertight and connection between house and addition is properly sealed to minimize 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 sealant and the characteristics of the penetration

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

Objective(s):
Ensure resulting closure is permanent and supports expected wind and mechanical pressure loads

Ensure sealant is effective and durable

3.1701.1g - Sealant selection

Desired Outcome:
The exterior of the seam is weathertight and connection between house and addition is properly sealed to minimize 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, if required

Objective(s):
Create a permanent seal

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

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:

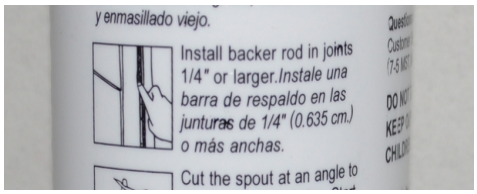
1. Caulk gun
2. Spray foam gun

Materials:

1. Caulk
2. Spray foam

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

3.1701.1h - Floor repair

Desired Outcome:
The exterior of the seam is weathertight and connection between house and addition is properly sealed to minimize air leakage and moisture movement between unconditioned and conditioned space

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

Holes in the floor should be repaired

Completed floor patches should be air sealed to prevent leakage from belly

Tools:

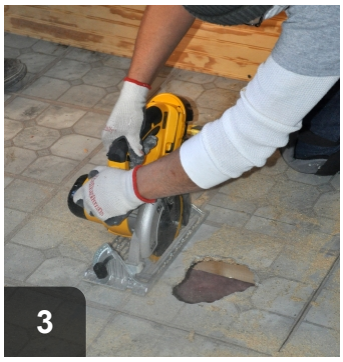
1. Saw
2. Tape measure
3. Caulk gun
4. Marker
5. Utility knife
6. Drill

Materials:

1. Plywood or other suitable subflooring material
2. Fasteners
3. Caulk
4. Sealant

When possible, measure patch to reach surrounding joist. If not, blocking will be required.

Mark damaged area to be removed to create most efficient patch



Cut out damaged area of floor, with minimal damage to surrounding floor and joists

Once damaged area has been removed, measure for new patch and cut replacement subflooring to size

Clean debris from surrounding area and mounting surfaces

Apply sealant to mounting surfaces

Securely fasten new subfloor in place, attaching to joist or blocking as necessary

Seal gaps around patched in subfloor to create air seal between conditioned living space and crawl space

3.1701.1i - Structural materials

Desired Outcome:

The exterior of the seam is weathertight and connection between house and addition is properly

sealed to minimize 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

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

Tools:

1. Caulking gun
2. Nail gun
3. Screw gun

Materials:

1. Nominal 2X framing lumber
2. 7/16" OSB or 1/2" CDX plywood
3. Nails or screws
4. Construction adhesive

3.1701.1j - Ceiling hole repair

Desired Outcome:
The exterior of the seam is weathertight and connection between house and addition is properly sealed to minimize 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

Replace any missing insulation and repair holes in vapor barrier

After

Drywall patch before final sand and prime

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 or nails
5. Support material if needed (typically 1X4, 1X6, or 2X4 dimensional lumber)

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. 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.

Replace any missing insulation and repair holes in vapor barrier

Prepare the hole by cutting the edges clean and square.

Cut drywall and fasten in place

Add joint tape and coat of joint compound

3.1701.1k - High temperature application

Desired Outcome:
The exterior of the seam is weathertight and connection between house and addition is properly sealed to minimize 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

Objective(s):
Prevent a fire hazard

Gaps around floor penetrations allow air and moisture movement

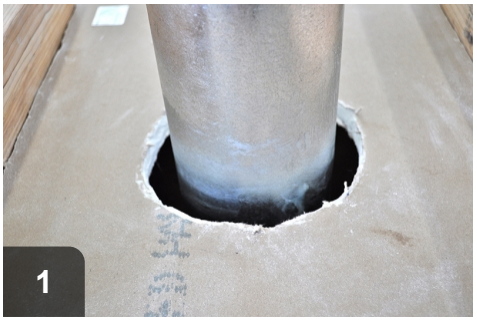
Use non-combustible materials, like 26-gauge steel and high-temp caulk

Tools:

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

Materials:

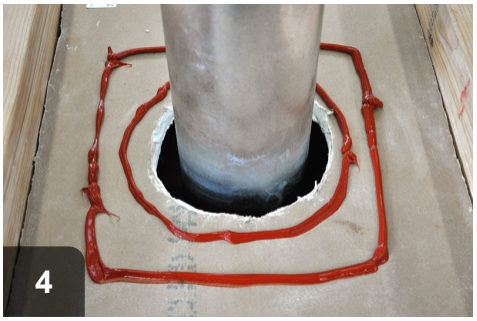
1. High-temperature caulk
2. Non-combustible material such as aluminum or galvanized steel flashing or cement board
3. Appropriate fasteners

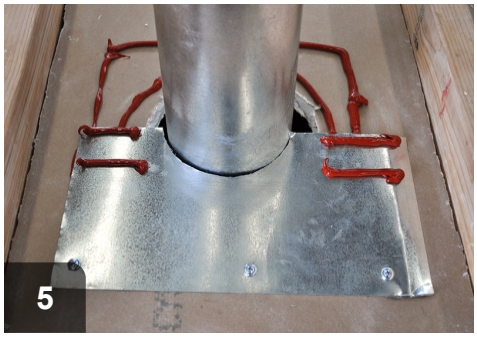


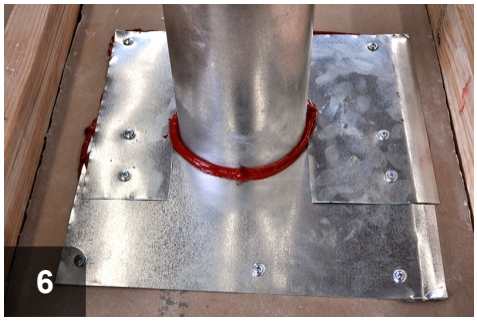
Prepare work area by removing any insulation and debris

Use high-temperature caulking (600F min)

Apply first ring of caulking to match shape of opening







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

Fasten rigid material and apply additional caulking

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

4.1003.8 - Installing Fiberglass Blown Insulation for Flat, Bowed, or Vaulted Ceilings (via Roof Side Lift)

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

4.1003.8a - Attic, ceiling, and roof verification

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

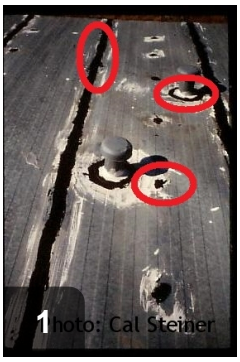
Tools:

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.



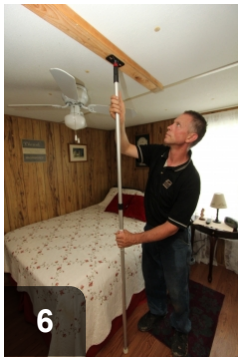
Inspect roof for evidence of water pooling, leaks, or damage. Verify proper vent terminations

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

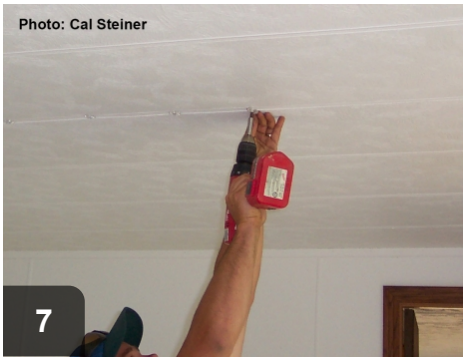
Verify presence of rain caps on all vents

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 - Attic access

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

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

Remove fasteners from the J-channel

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

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

Remove staples as necessary to lift roof and inspect underneath

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

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

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

4.1003.8c - Blowing machine set up

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

Before loading insulation, check that machine is operating properly and set up on a dry, level surface near power source

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

Tools:

1. Hex wrench
2. Pressure gauge

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 - Fiberglass blown insulation installation

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

In Progress

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 - Roof reattachment

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

If salvageable, clean J-channel before reinstallment

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

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 fasters, attach J-channel along roof seam and seal as necessary

4.1003.8f - Verification of details

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

4.1003.9 - Installing Fiberglass Blown Insulation for Flat, Bowed, or Vaulted Ceilings (via Exterior Access from Top of Roof)

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

4.1003.9a - Attic, ceiling, and roof verification

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 not 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 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

Before

Roof leak, missing cap on vent

After

Properly connected and sealed roof vent

Tools:

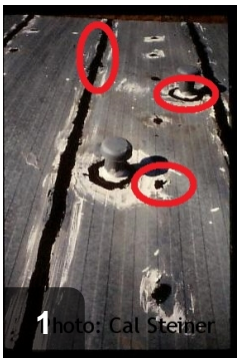
1. 2-1/2" hole saw
2. Power drill
3. Borescope
4. Inspection mirror
5. Flashlight

Materials:

1. Material requirements will vary based on conditions
2. Drywall or paneling
3. IC/Airtight recessed lights
4. Fire caulk
5. Vent terminations
6. Silicone caulk
7. Galvanized sheet metal and screws
8. Roof cement
9. Temporary ceiling bracing

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.



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

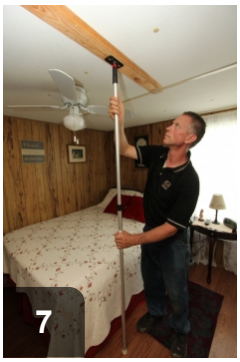
Inspect all patches and repairs, and correct deficiencies if necessary

Verify presence of rain caps on all vents

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

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

Repair and refasten sagging or unsecured ceiling panels. Caulk and seal seams to prevent insulation spilling into house



Use temporary supports to avoid ceiling collapse during insulation install

4.1003.9b - Attic access

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 through the gable vents.

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

Determine technique for installing insulation

In Progress

Manufactured home attic access by slicing along ridgeline

Tools:

1. 7-1/4" circular saw
2. Electric driil
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.

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

4.1003.9c - Blowing machine set up

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

Before loading insulation, check that machine is operating properly and set up on a dry, level surface near power source

Test to verify that machine is operating within manufacturer's limits

Tools:

1. Pressure gauge
2. Generator

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

4.1003.9d - Fiberglass blown insulation installation

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

Insulation will be filled no higher than the top of the truss

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

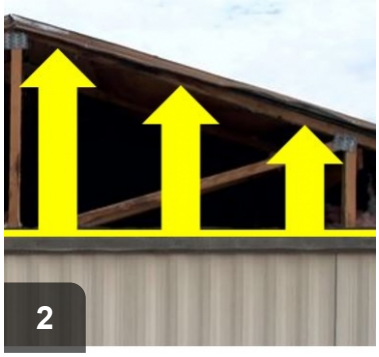
Allow roof to be returned to original position

Fire safety will be maintained

In Progress

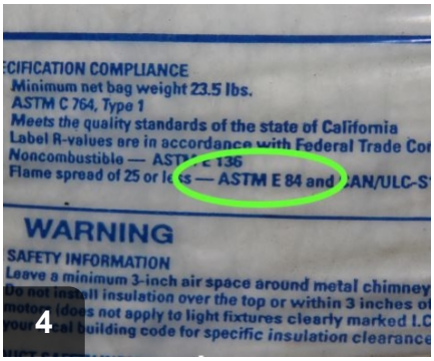
Always wear PPE appropriate to the work environment and job at hand.

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.

4.1003.9e - Patching and sealing openings

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

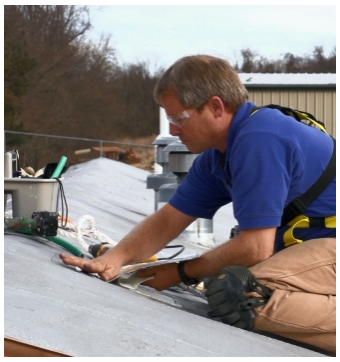
Insert 6" plug and seal around the perimeter of the opening.

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 - Verification of details

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

4.1003.10 - Installing Fiberglass Blown Insulation for Flat, Bowed, or Vaulted Ceilings (via Interior Access Through the Ceiling)

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

4.1003.10a - Attic, ceiling, and roof verification

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

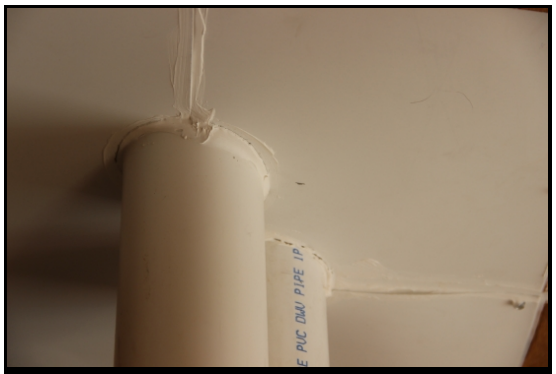
Ensure structural integrity of the roof and ceiling assembly

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.

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 - Construction prep

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

Bad Practice

Improperly prepared workspace with cellulose all over client belongings and bedroom

Best Practice

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 - Attic access

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

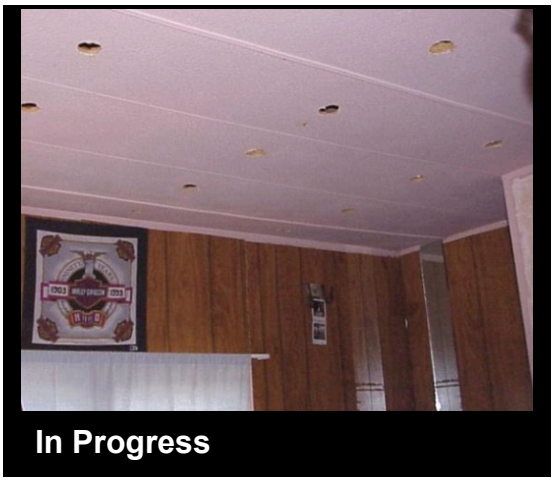
Attic will be visually inspected for the location of existing insulation, obstructions, hazards, and construction type

Objective(s):
Create access to the full attic cavity

Determine insulation installation technique

Prevent damage to ceiling

Create a professionally finished ceiling



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

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

Tools:

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

Materials:

1. protective plastic

4.1003.10d - Blowing machine set up

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

Before loading insulation, check that machine is operating properly and set up on a dry, level surface near power source

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

Tools:

1. Pressure gauge
2. Hex wrench

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

If testing shows machine is operating properly, attach hose and tighten

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

manufacturer's specifications fitting to minimize slippage

4.1003.10e - Fiberglass blown insulation installation

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

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

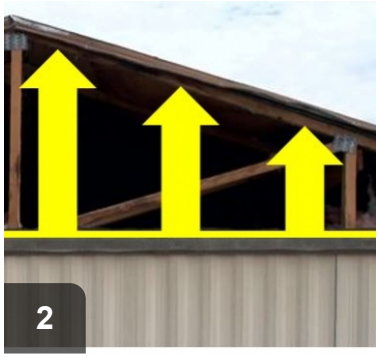
Avoid clogging of the cavity and the fill tube

Prevent damage to the ceiling

Fire safety will be maintained

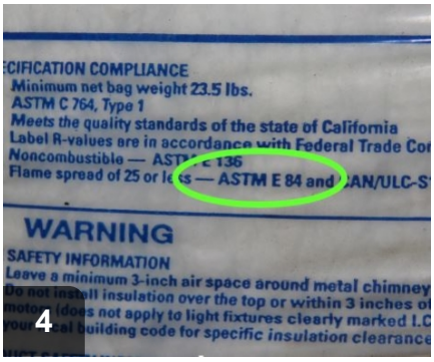
Attic insulation should be consistently installed in each cavity to the edge.

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.

4.1003.10f - Patching and sealing holes

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

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

Tools:

1. color matched plug

Materials:

1. color matched plug

4.1003.10g - Verification of details

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.

Best Practice

Document and repair any damage the workers caused.

4.1088.6 - Installing Insulation at Flat and Cathedral Ceiling Transition Wall

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

4.1088.6a - Insulation installation verification

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

Specification(s):
A visual inspection of the highest point of the transition wall will be completed

Access points will be determined from the gable end, roof, ceiling, or interior paneling

Objective(s):
Verify the height and the accessibility of the attic

4.1088.6b - Access attic

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

Specification(s):
Attic will be accessed through the location that allows the most efficient and effective insulation coverage

Objective(s):
Gain access to the flat and cathedral ceiling transition wall

4.1088.6c - Blowing

Desired Outcome:

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

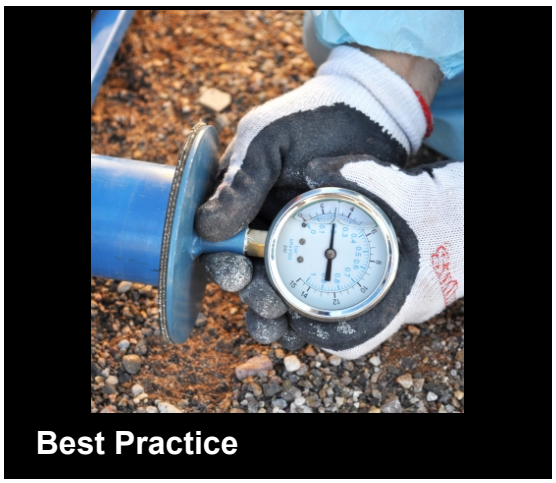
Specification(s):
Blowing machine pressure test will be performed with air on full, feed off, and gate closed

Insulation will be blown against the transition wall until the wall is covered

Objective(s):
Ensure machine is capable of delivering uniform insulation density and coverage to meet manufacturer specifications for loose blown insulation

Create a thermal barrier at the transition wall

Before loading insulation, check that machine is operating properly and set up on a dry, level surface near power source



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

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.

4.1088.6d - Spray two-part foam

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

Specification(s):
Insulation will be installed to prescribed R-value in accordance with manufacturer specifications

Spray polyurethane foam (SPF) will be applied to desired thickness, using pass thickness maximum as indicated by manufacturer

Objective(s):
Insulate and seal transition wall

4.1088.6e - Batt

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

Specification(s):
Batt insulation will be installed in accordance with manufacturer specifications without gaps, voids, compressions, misalignments, or wind intrusions

Insulation will be installed to the prescribed R-value

Vapor barrier will be installed based on regional considerations

Objective(s):
Insulate to prescribed R-value

4.1088.6f - Patching and sealing access points

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

Specification(s):
Created access points will be covered and sealed in an aesthetically pleasing manner

Existing access points (e.g., gable vent) will be returned to the original condition

If existing trim was removed, it will be reinstalled

Objective(s):
Create an airtight seal

Create an aesthetically pleasing finish

4.1088.6g - Verification of details

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.

Best Practice

4.1088.6h - Onsite Documentation

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

Specification(s):
A dated receipt signed by the installer will be provided that includes:

- Insulation type
- Coverage area
- R-value
  • Installed thickness and settled thickness (settled thickness required for loose-fill only) • Number of bags installed in accordance with manufacturer specifications (for loose-fill only)

Objective(s):
Document job completion to contract specifications Confirm amount of insulation installed Comply with 16 CFR 460.17

4.1104.1 - Stuffing Wall Cavities with Fiberglass Batts

Desired Outcome:
Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

4.1104.1a - Access wall cavities

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

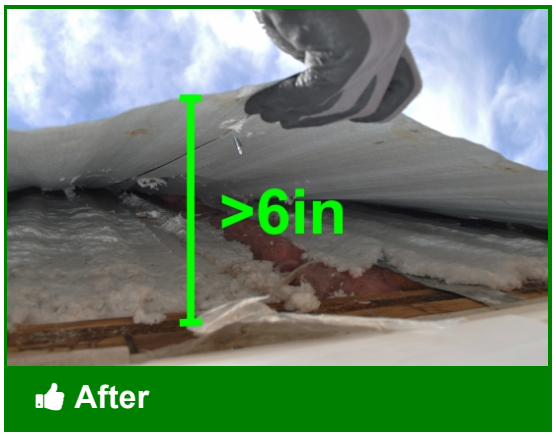
Fasteners will be removed from the bottom of the siding, working upward until the siding can be pulled away from the framing approximately 6" without damaging the siding

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

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



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

Tools:

1. Drill

If skirting overlaps siding, remove skirting

Temporarily fasten siding panels at joint to hold seam together

Seam should remain together with temporary fastener

4.1104.1b - Exterior wall cavity inspection

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

Before

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

In Progress

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

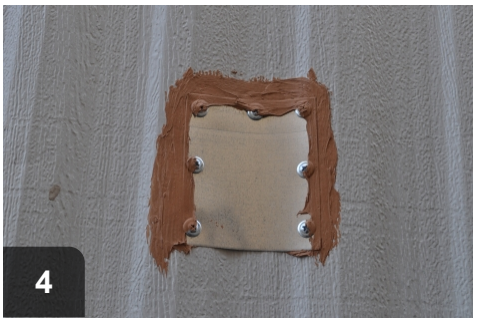
Materials:

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

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

Holes in exterior siding should be patched

Apply sealant to back of patch to maintain air barrier



Ensure that patch is securely fastened and water-tight

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

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

4.1104.1c - Fiberglass batt installation tool (stuffer)

Desired Outcome:
Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

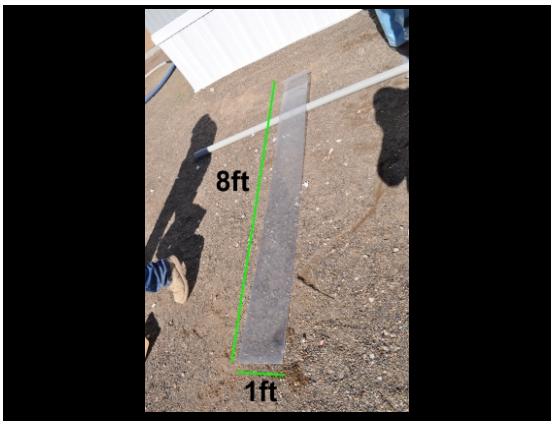
Specification(s):
A sheet of polycarbonate, such as Lexan, will be cut to the following specifications to create a stuffer tool:

- Approximately 1' x 8' x ¼" with a 5 degree bend 7' ½" 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

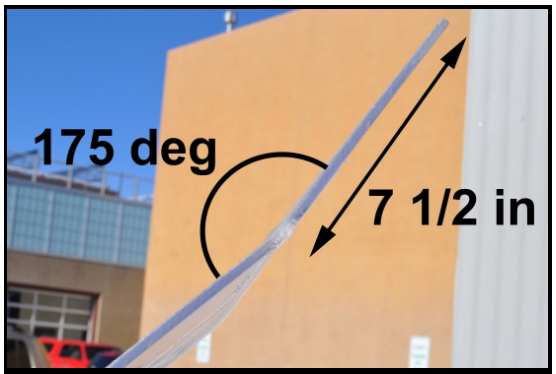
Objective(s):
Create a tool to install a fiberglass batt into the cavity

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 - Fiberglass batt installation

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

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

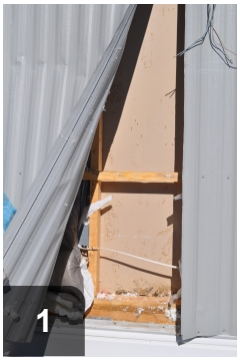
Fiberglass batt should fill entire cavity without creating bulging in exterior paneling

Tools:

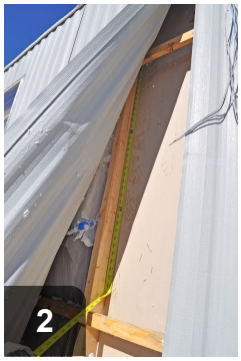
1. Tape measure
2. Utility knife

Materials:

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



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



Measure length of cavity

Measure depth of cavity

4

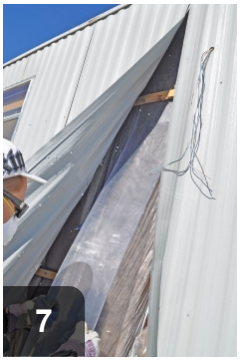
Select appropriate batt thickness and R-value. Wrapped batts provide a built in vapor barrier

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

4.1104.1e - Sub-sheathing patch and repair

Desired Outcome:
Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):
Subsheathing will be patched or repaired as necessary

Objective(s):
Ensure the integrity of the drainage plane

4.1104.1f - Reattachment

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

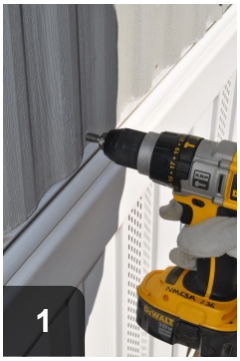
Once work is finished, reattach siding and skirting, ensuring neither have been damaged

Tools:

1. Drill

Materials:

1. Fasteners



Using new fasteners, reattach paneling

Reinstall skirting, if necessary

Reattach trim, if necessary

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

4.1104.1g - Onsite documentation

Desired Outcome:
Consistent thermal boundary and air barrier between the conditioned space and unconditioned space

Specification(s):
A dated receipt signed by the installer will be provided that includes:

- Coverage area
- Thickness
- R-value

Objective(s):
Document job completion to contract specifications

Confirm amount of insulation installed

Comply with 16 CFR 460.17

4.1303.1 - Insulation of Floor Cavity with Blown Material

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

4.1303.1a - R-value

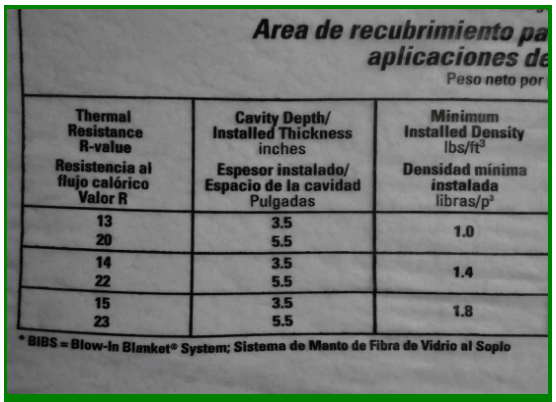
Desired Outcome:
Consistent thermal boundary between conditioned and unconditioned space that reduces heat flow

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 pa
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/ft³ / Densidad mínima instalada libras/p³
13 20	3.5 5.5	1.0
14 22	3.5 5.5	1.4
15 23	3.5 5.5	1.8

* 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

4.1303.1b - Work assessment

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

Specification(s):
Road and rodent barrier must be intact and free from holes and capable of supporting the insulation

Objective(s):

Ensure bottom board is intact

Ensure insulation is supported

Protect cavity from infestation

4.1303.1c - Insulate floors

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

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

Objective(s):
Eliminate voids and settling

4.1303.1d - Materials

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

Specification(s):
Flame spread index of selected materials will not exceed 25 with an accompanying smoke-developed index not to exceed 450 when tested in accordance with ASTM E84 or UL 723

Flame spread index of foam insulation will not exceed 75 and a smoke- developed index of no more than 450 when tested in the maximum thickness intended for use in accordance with ASTM E84 or UL 723

Foam insulation will be separated from the interior of the building by an approved thermal barrier at a minimum of 1/2" gypsum or a material that is tested in accordance with the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of NFPA 275

Selected material will be of minimal water absorbency

Selected material will be noncorrosive

Objective(s):
Ensure durability

Prevent moisture damage

Fire safety will be maintained

4.1303.1e - Occupant education

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:

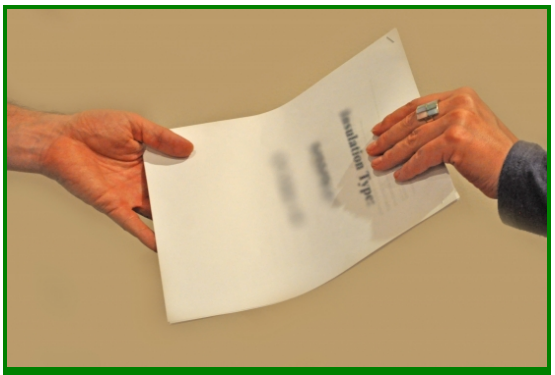
- Insulation type
- Coverage area
- R-value
- Installed thickness and minimum settled thickness
- Number of bags installed in accordance with manufacturer specifications

Objective(s):
Document job completion to contract specifications

Confirm amount of insulation installed

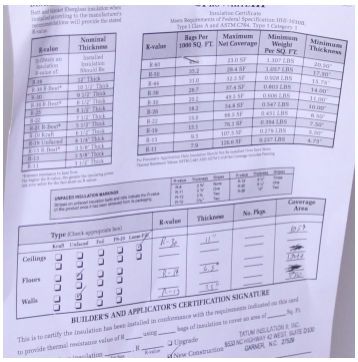
Ensure ability to match bags required for total area completed

Comply with 16 CFR 460.17

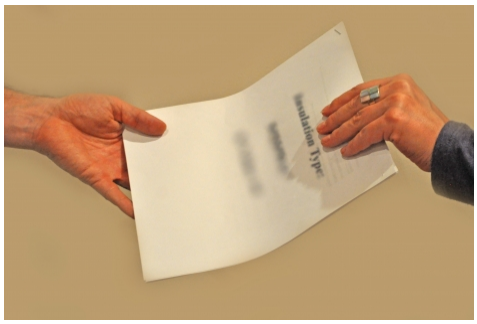


Best Practice

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



Documentation should include insulation material and r-value



Provide occupant with copies of all documentation

Communicate professionally with occupant to provide information and support

4.1303.2 - Insulation of Floor Cavity with Batt Material

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

4.1303.2a - R-value

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

Proper r-value is determined by climate zone, and should be listed in work order

Best Practice

Review work order and verify that proper R-value and thickness of batt is being used

Materials:

1. Fiberglass batts

4.1303.2b - Work assessment

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

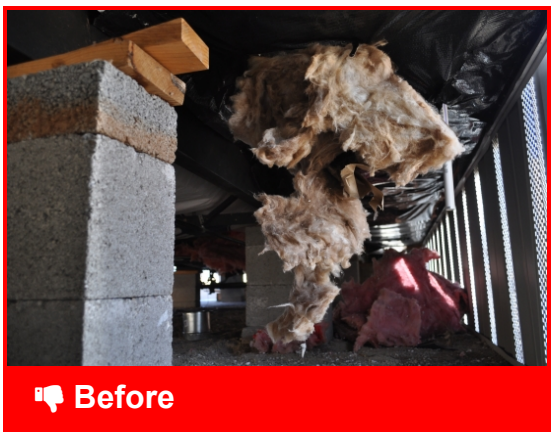
Specification(s):

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



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

Once cavity is cleared, it is ready for new insulation

Tools:

1. Utility knife

Remove old rodent barrier and insulation

Cavities should be completely cleared of debris

4.1303.2c - Insulate floors

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

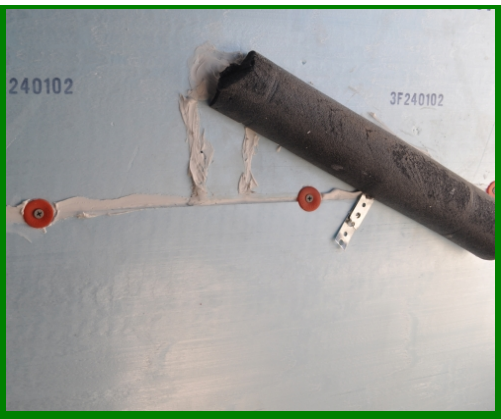
Ensure durability

Minimize convective heat transfer

Keep pipes from freezing

Before

Uninsulated floors over unconditioned spaces are an energy drain



After

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

Tools:

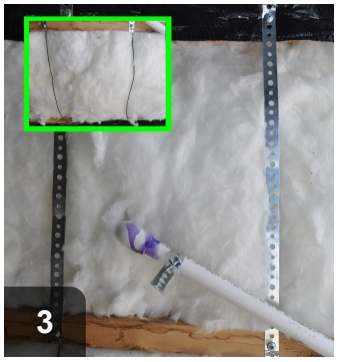
1. Utility knife
2. Tape measure
3. Metal snips
4. Drill
5. Caulk gun

Materials:

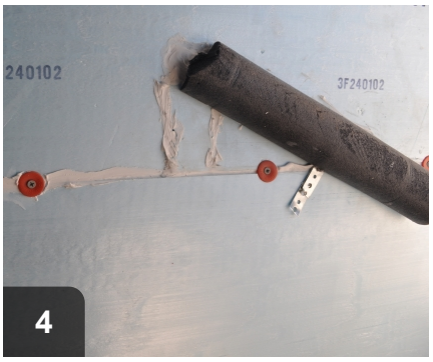
1. Fiberglass batts, may be kraft-faced
2. Metal tape
3. Insulation supports (lightning rods)
4. Fasteners
5. Caulk
6. Duct insulation

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

Notch insulation around pipes, blocks, and other obstructions



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



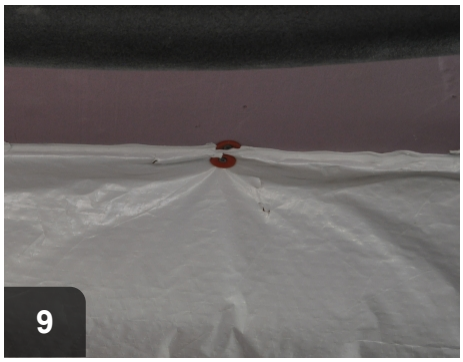
A rigid air barrier should be securely in place so prevent sagging, gaps and penetrations should be sealed

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

Water lines and ducts should be insulated if running below joists

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

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



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

4.1303.2d - Materials

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 IRC

Foam plastic insulation will comply with IRC

Fasteners will be corrosion resistant

Objective(s):
Ensure durability

Prevent moisture damage

Bad Practice

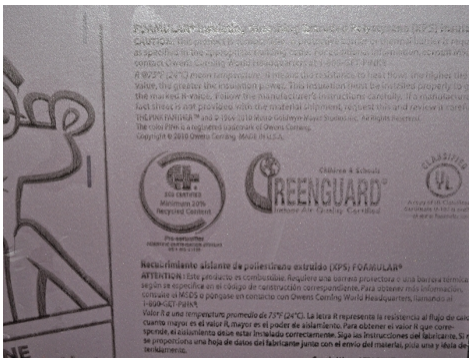
Do not use absorbent insulation material, such as cellulose, in the floor cavity

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



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

4.1303.2e - Occupant education

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

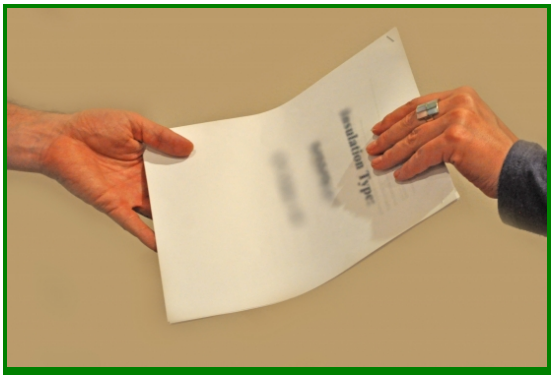
Specification(s):
A dated receipt signed by the installer will be provided that includes:

- Coverage area
- Thickness
- R-value

Objective(s):
Document job completion to contract specifications

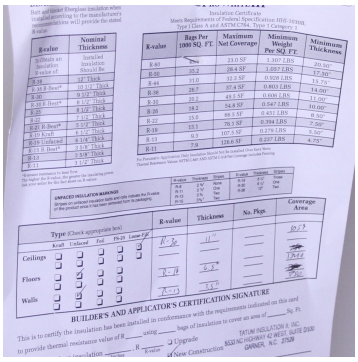
Confirm amount of insulation installed

Comply with 16 CFR 460.17

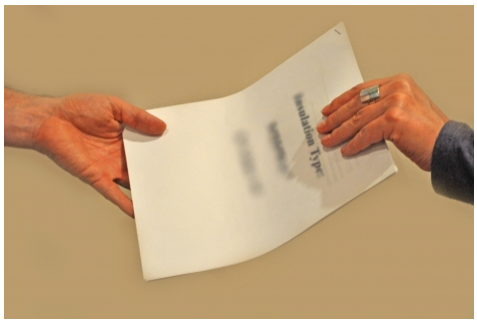


Best Practice

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



Documentation should include insulation material and r-value



Provide occupant with copies of all documentation

Communicate professionally with occupant to provide information and support

4.1402.2 - Basement Wall Insulation—No Groundwater Leakage

Desired Outcome:
Basement insulation improves thermal performance and ensures sufficient drying potential

4.1402.2a - R-value

Desired Outcome:
Basement insulation improves thermal performance and ensures sufficient drying potential

Specification(s):
Regional IECC will be followed for required R-values

Objective(s):
Improve thermal performance of the basement and living space

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

Best Practice

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

4.1402.2b - Air barrier

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

XPS insulation board is a non-absorbent insulation option

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

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

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

4.1402.2c - Vapor permeability

Desired Outcome:
Basement insulation improves thermal performance and ensures sufficient drying potential

Specification(s):
When absorbent insulation materials are installed, assembly will remain vapor semi-impermeable to the interior in all climate zones except Zone 7

Objective(s):
Provide drying potential to the basement

Before

Kraft-faced fiberglass insulation is absorbent

After

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

Tools:

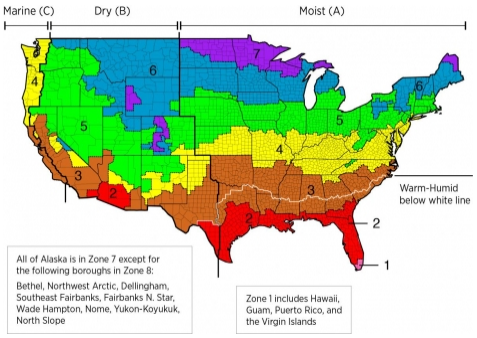
1. Utility knife
2. Tape measure
3. Drill
4. Taping knife

Materials:

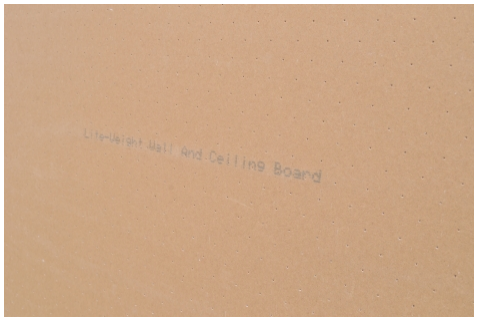
1. XPS insulation board
2. Drywall
3. Kraft-faced fiberglass batts
4. Spackle
5. Seam tape
6. Fasteners

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, SWS calls for materials with a perm rating of <0.5 (which translates to 4mil or thicker). From 2007 IRC definition of vapor retarders: Class I: ≤ 0.1 perm (called impermeable), Class II: 0.1 to 1.0 perm (called semi-impermeable), Class III: 1.0 perm to 10 perms (called semi-permeable).



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

4.1488.1 - Climate Considerations for Insulating Water Lines Located Between Bottom Board and Ground

Desired Outcome:
Water supply line does not freeze in cold climates

Note:

4.1488.1a - Work assessment

Desired Outcome:
Water supply line does not freeze in cold climates

Specification(s):
Installer prework assessment will be conducted to determine:

- Water leaks do not exist
- Accessibility

Water leaks will be repaired before installation

Objective(s):
Verify scope of work

Ensure that work space is safe and ready for work

4.1488.1b - Installation

Desired Outcome:
Water supply line does not freeze in cold climates

Specification(s):
Pipe freeze protection system will have thermostatic heat control and circuit protection

Insulation will be installed over pipe freeze protection system when necessary

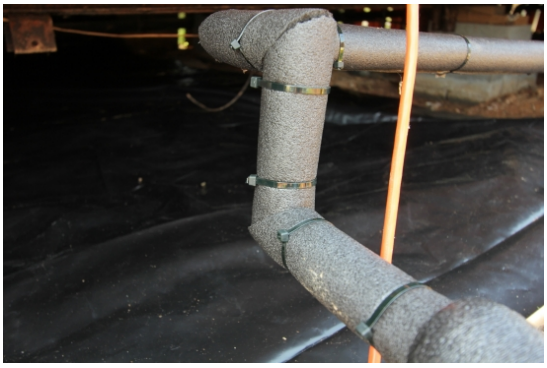
Pipe will be protected from wind

Objective(s):
Ensure fire safety

Protect supply pipe from freezing

In Progress

Properly installed freeze protection heat tape



After

Insulated, freeze protected water line

Tools:

1. Utility knife
2. Rags

Materials:

1. Heat tape
2. Zip ties (to attach thermostat)
3. Electrical tape
4. 1/2" thick fiberglass insulation

To prevent pipe freezing and reduce the risk of fire, follow manufacturer's instructions carefully. Choose the proper length heat tape for the pipe to be protected. When using multiple lengths of heat tape on long pipes, start subsequent runs of heat tape one foot before the end of the previous run on opposite sides of the pipe. Never overlap or cross heat tape with itself. Complete heat tape installation instructions may be found here: https://www.foremost.com/mygreathome/mobile-home-repair/seasonal/how-to-install-heat-tape.asp

Install thermostat in firm contact with the pipe at the coldest point

Fasten heat tape to pipe with electrical tape every six inches.

Measure and cut insulation to fit water lines. Miter insulation at elbows and tees

Fasten insulation to water lines with zip ties

Cover all exposed portions of the water supply lines with insulation

4.1488.1c - Occupant education

Desired Outcome:
Water supply line does not freeze in cold climates

Specification(s):
Occupants will be educated on efficient and safe operation and maintenance of heat tape

Objective(s):
Ensure safe and durable protection of water line

Best Practice

Educate occupant on effective and safe use of heat tape

Materials:

1. Heat tape manufacturer's operating instructions

A good guide for homeowner education may be found here:

https://www.foremost.com/mygreathome/mobile-home-repair/seasonal/how-to-install-heat-tape.asp

4.1601.3 - Insulation and Vapor Barrier

Desired Outcome:
Minimize condensation

Note:

4.1601.3a - Ducts in unconditioned spaces (e.g., crawl space, attic, unconditioned basements)

Desired Outcome:
Minimize condensation

Specification(s):
Ducts will have continuous insulation and vapor barrier

Insulation will be sufficient to prevent dew point on surface of ducts

Objective(s):
Minimize condensation

Insulation and vapor barrier should be continuous in unconditioned spaces to prevent condensation on ducts

Materials:

1. Pipe wrap
2. Seam tape
3. Tie bands

4.1601.3b - Ducts within floor assemblies

Desired Outcome:
Minimize condensation

Specification(s):
Inspection and/or testing will be conducted to determine whether ducts are within thermal, pressure, and vapor boundary

If ducts are within thermal, pressure, and vapor boundary, no action will be required

If ducts are not within thermal, pressure, and vapor boundary, continuous air barrier, insulation, and vapor retarder will be installed either on the ducts or at the belly liner

Objective(s):
Minimize condensation

Best Practice

Test duct performance using pressure pan or duct blaster to determine whether ducts align with the thermal boundary

Best Practice

Insulate and seal as necessary based on diagnostic testing and inspection, to limit condensation

4.1601.3c - Exposed metal

Desired Outcome:
Minimize condensation

Specification(s):
All exposed metal will have continuous insulation and vapor retarder

Objective(s):
Minimize condensation

4.1601.3c - Exposed metal

Best Practice

Repair holes in belly which would expose metal components to potential condensation

Best Practice

Metal components that extend beyond the belly must be insulated and have a vapor barrier

4.1601.4 - Insulating Flex Ducts

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

Note:

4.1601.4a - Removal of existing flexible ducting

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

Specification(s):
All accessible low R-value flexible ducting will be removed from premises

Objective(s):
Ensure installation of proper R-value ducts

Before

Remove existing flex duct that does not meet the requirement of R-8.0

Best Practice

Replace with ducting insulated to a minimum of R-8

4.1601.4b - Selection of new flexible ducting

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

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

All replacement ducting should be R-8.0, minimum

Tools:

1. Tie band tensioner

Materials:

1. Flex duct, min R-8

4.1601.4c - Sizing of new flex

Desired Outcome:

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

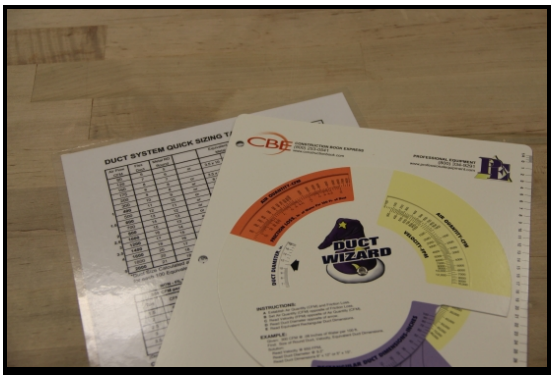
Specification(s):

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 - Installation of flex

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

Elbows are required when a change in direction is needed.

4.1601.4e - Interior liner attachment

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:

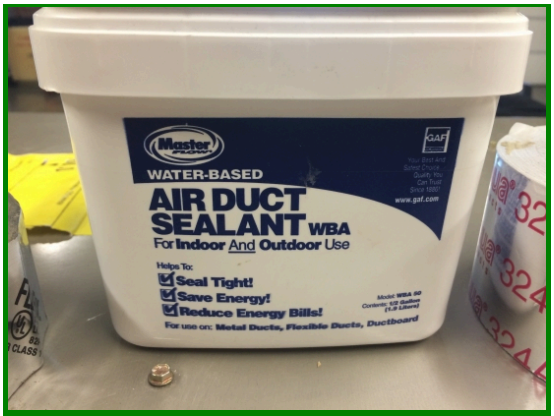
1. tie band

4.1601.4f - Sealing of interior liner

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 - Attachment of exterior liner

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

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

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

Trim the excess tie band material.

4.1601.4h - Sealing of all accessible ducts

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

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

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 - Insulation of all fittings

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

This elbow has been sealed, but is not insulated.

Fitting has been sealed and properly insulated.

4.1601.4j - Completeness of vapor barrier

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

After

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 - Vermin proofing

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.

4.1601.4l - CAZ testing

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

Specification(s):
CAZ testing will be performed where combustion appliances are utilized

Objective(s):
Identify unsafe equipment operating conditions

Best Practice

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

See SWS 2.0201.1 and SWS 2.0201.3 for CAZ testing

Tools:

1. Manometer
2. Mirror
3. Chemical smoke pencil
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 2.0201.1 and 2.0201.3.

4.1601.5 - Insulating Metal Ducts

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

Note:

4.1601.5a - Selection of duct insulation material

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

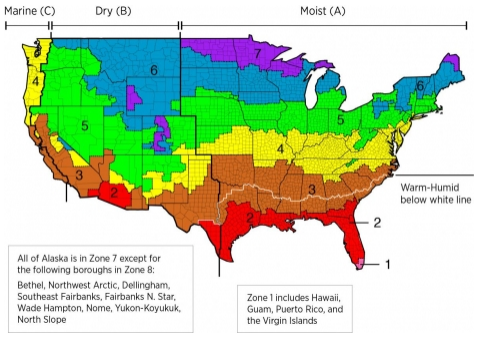
Uninsulated ducts in unconditioned spaces are an energy drain

After

Properly insulated ducts operate at much higher rates of efficiency

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

4.1601.5b - Duct sealing

Desired Outcome:

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

Specification(s):

All accessible ducts will be sealed with a UL-181 mastic before insulation is applied

Objective(s):

Minimize duct leakage

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

Sealed ductwork connections help prevent leakage

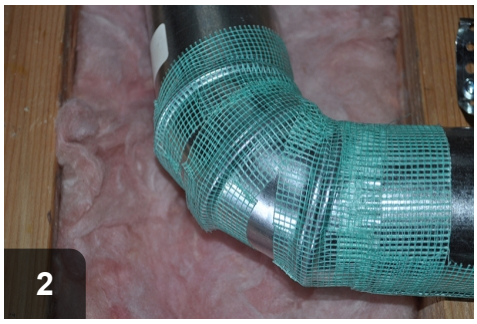
Tools:

1. Putty knife

Materials:

1. UL-181 mastic
2. Fiberglass mesh tape

Prepare work area by assessing any safety concerns



Wrap joint with fiberglass mesh tape

Apply UL 181 mastic to seal joint

4.1601.5c - Attachment of duct insulation

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 - Taping of the vapor barrier

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

4.1601.5e - Vermin proofing

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

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

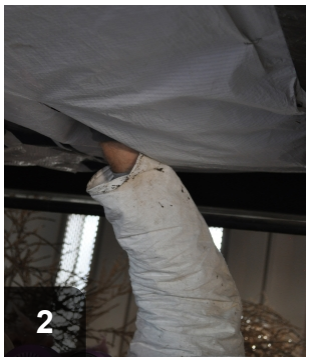
Before

Holes in air barrier should be patched to deter vermin

After

Ensure that patch is well sealed and securely fastened

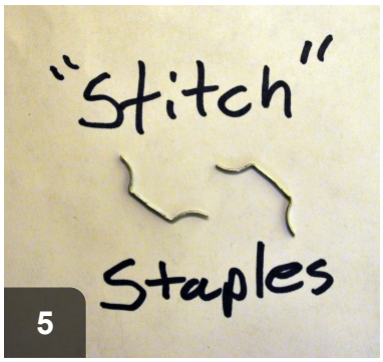
Holes in ducting should be patched to discourage vermin



Holes in belly air barriers allow vermin access to insulation and ducting

Use adhesive patch to air seal

Stitch staple patch to securely fasten physical barrier

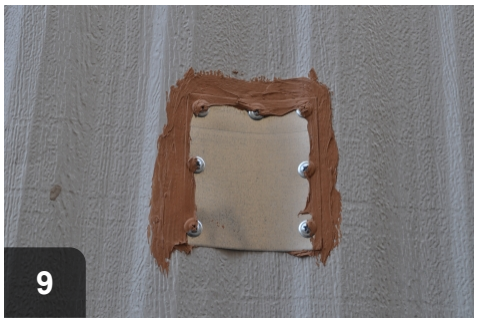


Stitch staples bend outward to hold in place for the long-term

Holes in exterior walls are another point of vermin entry

Apply sealant to back of patch to maintain air barrier

Flex patch to contour to wall



Securely fasten patch in place with screws and apply addition sealant to deter water

5.3001.3 - Replace Return Air Systems that Incorporate Floor Cavity (Belly) and/or Attic as the Return Air Pathway

Desired Outcome:
Effective, efficient, safe, and durable return air system

Note:

5.3001.3a - Close return air openings

Desired Outcome:
Effective, efficient, safe, and durable return air system

Specification(s):
Existing return air openings will be closed off and sealed with a durable material equivalent in strength to the surrounding material

Disturbed materials suspected to contain asbestos or lead content will be assessed and removed in accordance with EPA regulations

Objective(s):
Minimize air leakage

Improve indoor environmental quality

Ensure safe and legal renovation

5.3001.3b - Alternate return air system

Desired Outcome:
Effective, efficient, safe, and durable return air system

Specification(s):
Alternate return air opening will be provided to the furnace closet (e.g., replace louvered door or install grilles); whenever possible, follow manufacturer specifications for amount needed

Return duct design will be in accordance with ANSI/ACCA 1 Manual D Residential Duct Systems

A continuous and adequate return air pathway to the air handler will be installed

Objective(s):
Ensure sufficient return air is provided to the system

5.3001.3c - Zone pressure test

Desired Outcome:
Effective, efficient, safe, and durable return air system

Specification(s):
Pressures will be measured with the furnace fan operating across interior doors that can be closed and have a supply and/or return behind them

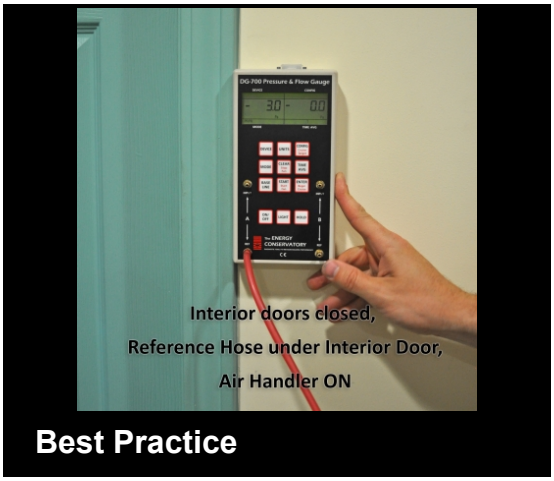
Rooms should not exceed 3 pascals of pressure

Pressure testing will be performed with all interior doors closed and the air handler running

Objective(s):
Ensure sufficient return air is provided to the system

Minimize moisture intrusion from negative pressures

Improve indoor air quality



With reference hose under closed interior door, test zonal pressure in rooms throughout house

Zonal pressure differential should be between 3pa and -3pa (e.g., 0 is good, +/-4 is not acceptable)

Tools:

1. Manometer
2. Reference hose

5.3001.3d - Combustion Appliance Zone (CAZ) testing

Desired Outcome:
Effective, efficient, safe, and durable return air system

Specification(s):
CAZ testing will be performed where combustion appliances are utilized

Objective(s):
Identify unsafe equipment operating conditions

Best Practice

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

See SWS 2.0201.1 and SWS 2.0201.3 for CAZ testing

Tools:

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

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 2.0201.1 and 2.0201.3.

5.3001.3e - Occupant education

Desired Outcome:
Effective, efficient, safe, and durable return air system

Specification(s):
Occupant will be educated on changes, how to operate and maintain the system, and any potential health concerns (e.g., lead, asbestos)

Objective(s):
Ensure occupant is educated

5.3003.1 - Data Plate Verification

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

5.3003.1a - Data plate verification

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 where available

Objective(s):
Ensure technician has equipment data necessary for commissioning and future service work

5.3003.3 - Evaluating Air Flow

Desired Outcome:
Air flow is properly tested

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

5.3003.3a - Total air flow

Desired Outcome:
Air flow is properly tested

Specification(s):
Total system air flow will be measured by one of the following methods:

- Temperature rise
- Flow plate
- Fan depressurization device(e.g., Duct Blaster®, DucTester®)

Objective(s):
Ensure equipment:

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

5.3003.3b - External static pressure

Desired Outcome:
Air flow is properly tested

Specification(s):
External static pressure will be in accordance with manufacturer specifications

Objective(s):
Ensure equipment:

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

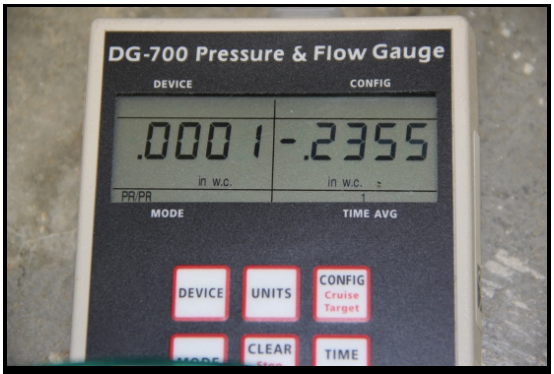
5.3003.3c - Pressure

Desired Outcome:
Air flow is properly tested

Specification(s):
Pressure drop across cooling coils will be in accordance with manufacturer specifications

Objective(s):
Ensure equipment:

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



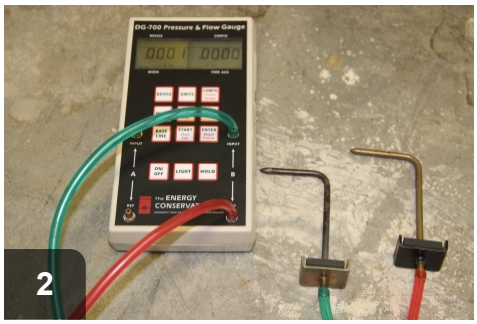
Best Practice

Pressure drop across the coil should be less than or equal to manufacturer recommendations, generally less than .3" w.c.

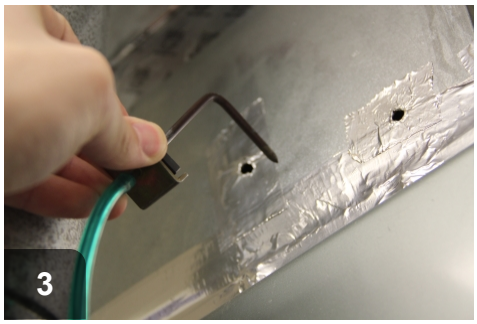
Tools:

1. manometer
2. static pressure probes
3. 1/4" hoses

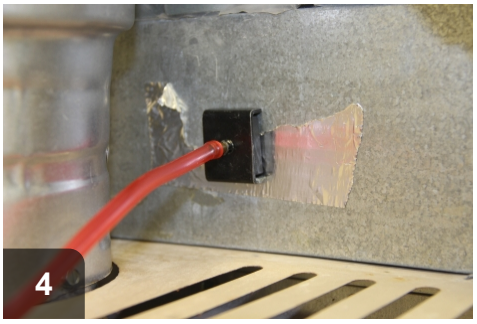
Drill holes being careful not to damage the evaporator coil.



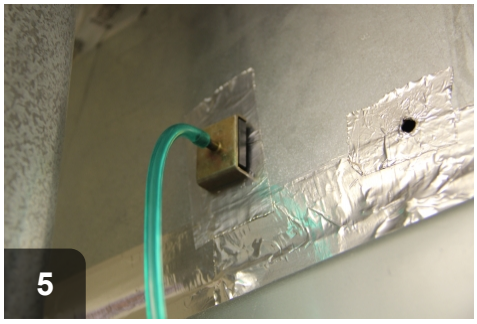
Hook gauges up to measure pressure before and pressure after the coil.



Static pressure probe should be inserted with the tip pointing into the air stream.



Probe placed before the coil.



Probe placed after the coil.

Measure resulting pressure drop of the dry evaporator coil.

5.3003.3d - Filter Inspection

Desired Outcome:
Air flow is properly tested

Specification(s):
Visual inspection to verify filter type is per manufacturer specifications, and is clean

Objective(s):
Ensure equipment:

- Operates as designed

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

5.3003.3e - Balancing room flow: new ductwork

Desired Outcome:
Air flow is properly tested

Specification(s):
Proper air flow delivery to each room will be ensured by one of the following:

Measuring air flow at each register

OR

Measuring heat rise, room pressures, and interviewing residents to ensure their comfort.

Objective(s):
Ensure equipment:

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

5.3003.3f - Supply wet bulb and dry bulb

Desired Outcome:
Air flow is properly tested

Specification(s):
Supply and return wet bulb (wet bulb temperature is measured for cooling systems only) and dry bulb air temperatures will be recorded

Objective(s):
Ensure equipment:

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

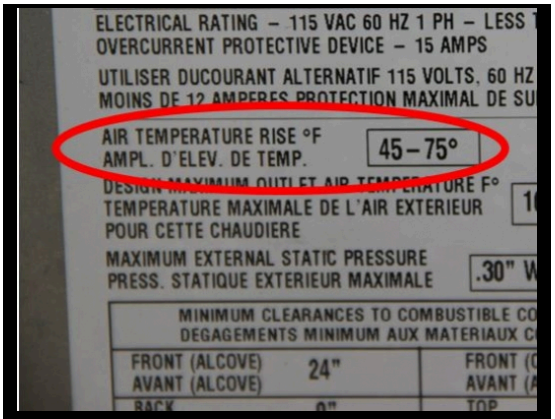
5.3003.3h - Temperature rise: gas and oil furnaces only

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



Best Practice

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.

Measure the temperature inside the combustion closet or the return nearest to the unit.

Return temperature is 88.5 degrees.

Measure the outgoing air temperature of the nearest supply register. Supply temperature is 116.8.

5.3003.5 - Refrigerant Line Inspection

Desired Outcome:
Refrigerant lines properly installed

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

5.3003.5a - Insulation

Desired Outcome:
Refrigerant lines properly installed

Specification(s):
All suction or vapor refrigerant lines, will be insulated to a minimum of R-4

High-side or liquid refrigerant lines will not be insulated unless specified by the equipment's manufacturer

Objective(s):
Ensure refrigerant lines do not gain excessive heat, or cause condensation to occur inside the building envelope

5.3003.5b - Ultraviolet (UV) protection of insulation

Desired Outcome:
Refrigerant lines properly installed

Specification(s):
If exposed to sunlight, refrigerant line insulation will be protected from UV degradation in accordance with manufacturer specifications, IRC or local code

Objective(s):
Install insulation so it does not degrade

Bad Practice

Line set insulation is exposed to direct sunlight and is severely degraded.

Best Practice

Line set insulation is protected with integrated UV protection. Tapes and other sealants may be required.

5.3003.5c - Sizing

Desired Outcome:
Refrigerant lines properly installed

Specification(s):
Refrigerant lines will be sized to meet manufacturer specifications for the installed equipment

Objective(s):
Ensure system moves appropriate volume of refrigerant

5.3003.5d - Installation quality

Desired Outcome:
Refrigerant lines properly installed

Specification(s):
Refrigerant lines will be installed without kinks, crimps, or excessive bends

Objective(s):
Ensure system moves appropriate volume of refrigerant

5.3003.5e - Support

Desired Outcome:

Refrigerant lines properly installed

Specification(s):
Refrigerant lines will be routed, supported, and secured to house in a manner that protects the line from damage by workers or occupants

Objective(s):
Ensure refrigerant lines do not move, vibrate, or sag

Protect lines from damage

5.3003.8 - Evaporative Cooler Maintenance and Repairs

Desired Outcome:
Evaporative cooler evaluated and maintained as needed

5.3003.8a - Assessment and diagnosis

Desired Outcome:
Evaporative cooler evaluated and maintained as needed

Specification(s):
The following system elements will be assessed:

- Pump
- Pan
- Spider
- Float
- Damper
- Roof jack support
- Water line
- Water valve
- Electrical
- Pads
- Motor
- Fan

Elements will be repaired or replaced as needed in accordance with manufacturer instructions

Objective(s):
Ensure all components function properly

Assess wear and tear on various parts of evaporative cooler

Pads have deposits and are shrunken from age. Replace

Pump needs to be cleaned of calcium deposits

Pan has calcium deposits as well but still holds water

Check spider, which distributes water to pads, for cracks and leaks

The float, attached to the water valve, shows no signs of cracking

The damper needs to be opened at the beginning of summer

The roof jack shows some signs of cracking and should be resealed

Water line is in tact and not leaking

Water valve has signs of deposits, but isn't leaking

Motor and electrical are in good working order

5.3003.8b - Repair and maintenance

Desired Outcome:
Evaporative cooler evaluated and maintained as needed

Specification(s):
Calcium deposits will be removed

Pads will be replaced

Any additional repairs or replacements will be made as necessary in accordance with manufacturer's instructions

Objective(s):
Protect the potable water supply from cross-contamination

Ensure evaporative cooler functions properly

Before

Old swamp cooler pad on left needs replacement due to calcium depositing

After

Pads have been replaced; calcium deposits have been removed. Ready to run

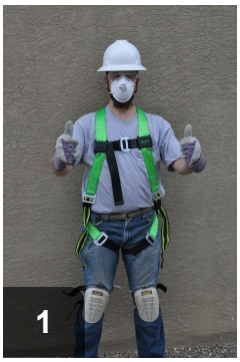
Tools:

1. Large vessel

Materials:

1. Scrub pads
2. Distilled white vinegar

See also SWS 2.0100.1f and 2.0100.1l for Health & Safety measures.



When working on a roof, always be sure to wear a fall-protection harness and proper PPE

Use vinegar both as a soak and on scrub pads to remove calcium deposits

Scrub calcium deposits off all surfaces, including trickle trough

Exterior deposits should also be cleaned. Can you tell which part is clean?

Measure and cut, if necessary, new pads designed for use in swamp coolers

Reinstall new pads, held in place with metal bracketing

5.3003.8c - Occupant education

Desired Outcome:

Evaporative cooler evaluated and maintained as needed

Specification(s):

A regular service schedule will be recommended to occupant

Issues regarding multiple systems running will be discussed with occupant

Objective(s):

Ensure the occupant understands basic operation and the importance of regular maintenance

Occupants with evaporative coolers should be alerted to proper maintenance

Communicate professionally with occupant to provide information and support

Standard Evaporative Cooler Maintenance
Spring (Start-Up)
Clean Pump
Clean Spider Nozzles and Drip Trough
Oil Blower and Motor Bearings - DO NOT Over Oil
Change Pads
Check Belt Condition and Tension (3/4" deflection @ 3lb. Force)
Check water bleed-off and clear any clogs
Remove damper/baffle (if present)
Plug in motor and pump
Turn-on/Reconnect Electricity
Mid-season Checks
Clean/Replace Pads - depends on water quality
Winter Shut Down
Turn-off/Disconnect Electricity
Drain Water (pan and all lines)
Unplug motor and pump
Insert damper/baffle (if equipped)
Cover unit

Review properly and timely evaporative cooler maintenance

Explain evaporative and refrigerative cooling should not be run together

5.3003.11 - Heating and Cooling Controls

Desired Outcome:
Heating and cooling controls installed and set properly

5.3003.11a - Removal of mercury- based thermostats

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

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.

5.3003.14 - Combustion Analysis of Gas-Fired Appliances (LP and Natural Gas)

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

5.3003.14a - Gas Pressure

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

Specification(s):
Measurement will be verified by a certified professional in accordance with fuel type and manufacturer specifications

Objective(s):
Ensure equipment:

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

Best Practice

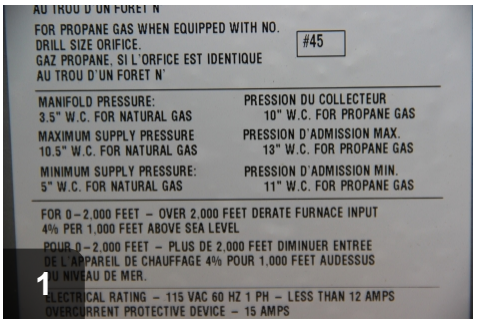
Natural gas should have a manifold pressure of 3.5" w.c.

Best Practice

Propane should have a manifold pressure of 10" w.c.

Tools:

1. Gas pressure gauge



See the manufacturer's specifications for desired manifold pressure

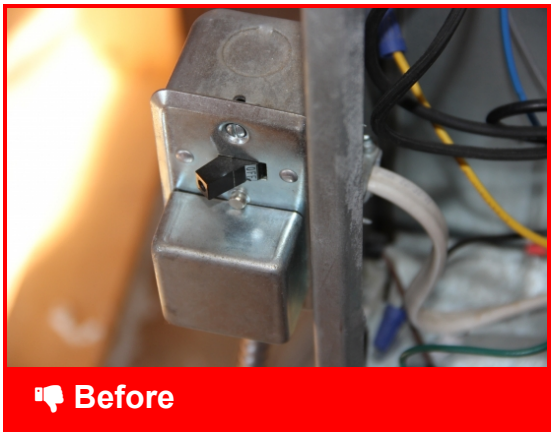
5.3003.14b - Place appliance in operation

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

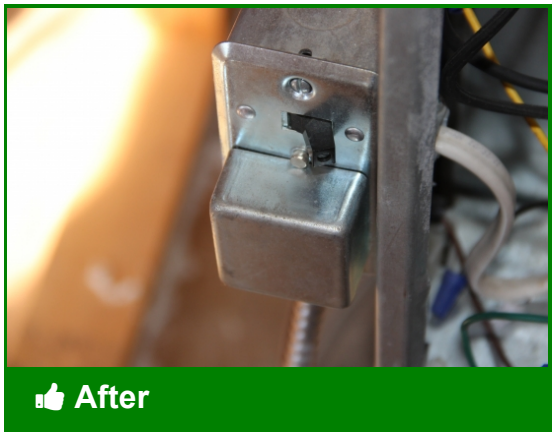
Specification(s):
Heating equipment will be placed in operation in accordance with applicable NFPA standards and manufacturer specifications when available

Objective(s):
Ensure equipment:

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



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



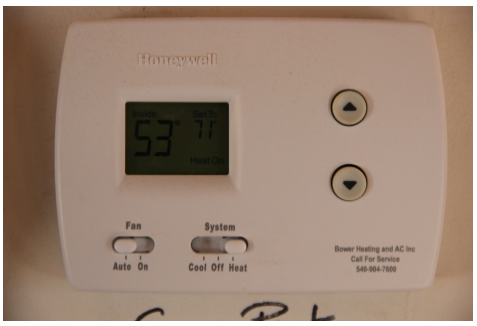
Appliance is set to ON at the disconnect and can now fire

Ensure appliance is fired is accordance with manufacturer's specifications.

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 - Carbon dioxide (CO2)and oxygen (O2)

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

5.3003.14d - Carbon monoxide (CO) in flue gas

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 400 ppm air-free

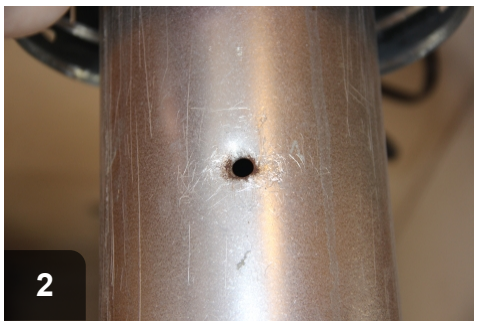
Objective(s):
Ensure equipment:

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

Best Practice

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

Direct vent appliances have concentric venting. The inner liner exhausts flue gas and the outer draws in combustion air



Ensure that the test ports drilled penetrate into the flue. Be sure to drop the outer liner into position before testing

With the test ports lined up on the inner and outer pipe, measurements can be taken in undiluted flue gas.

5.3003.14e - Testing/inspection holes

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

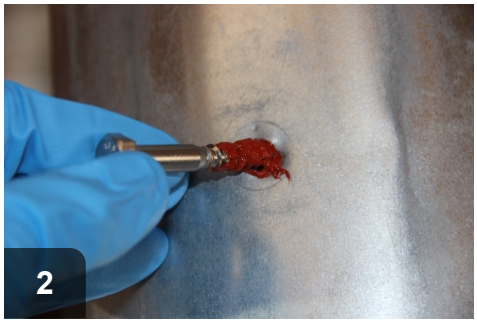
The testing hole was left unsealed.

The hole in both walls has been properly sealed with a plug, cap, or other approved method.

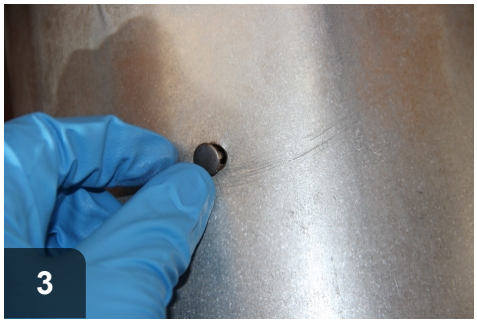
Materials:

1. high temperature sealant
2. stainless steel plug or cap
3. stainless 5/16" bolt

Apply high temperature sealant to the bolt, so that both holes will be sealed.



Screw the bolt into place, ensuring a proper seal on both pipes.



If sealing each wall individually, insert the plug into each hole.

Apply high temperature sealant to the perimeter of the plug.

5.3003.15 - Combustion Analysis of Oil-Fired Appliances

Desired Outcome:
Analysis of critical components and operations completed to industry and manufacturer specifications

5.3003.15a - Oil system: smoke test

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:

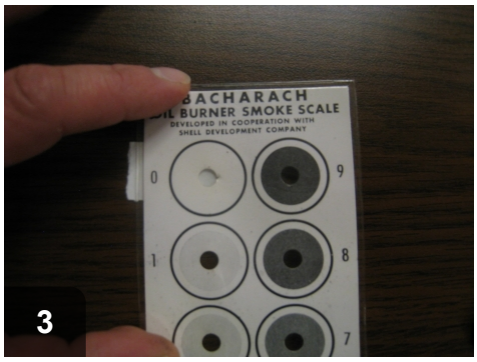
1. Smoke testing pump

Materials:

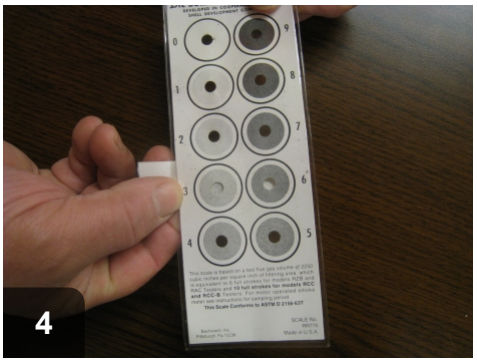
1. Filter paper

Place filter paper in testing pump and draw air through paper

Remove paper and verify draw was successful by checking for soot



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



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

5.3003.15c - Oil filter

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

5.3003.15d - Fuel pressure

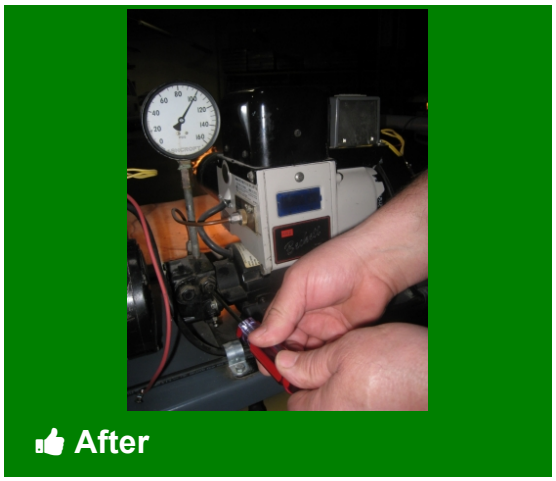
Desired Outcome:
Analysis of critical components and operations completed to industry and manufacturer specifications

Specification(s):
Measurement will be verified in accordance with manufacturer specifications

Objective(s):
Ensure equipment:

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

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



Verify that fuel pressure matches manufacturer's specifications

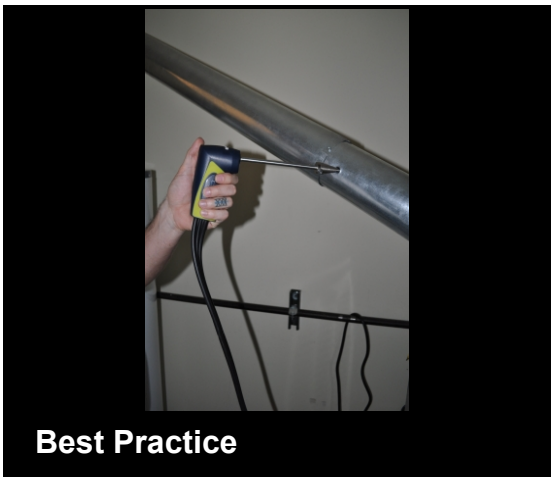
5.3003.15e - Oil system: steady state efficiency (SSE)

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



Test flue gases to determine steady state efficiency

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

Tools:

1. Combustion analyzer with probe

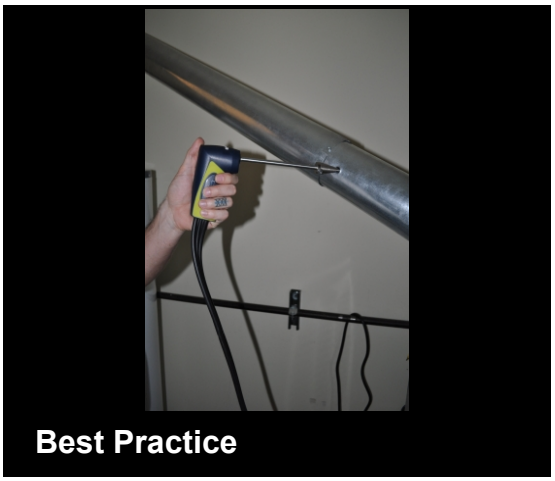
5.3003.15f - Net stack temperature

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



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

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.

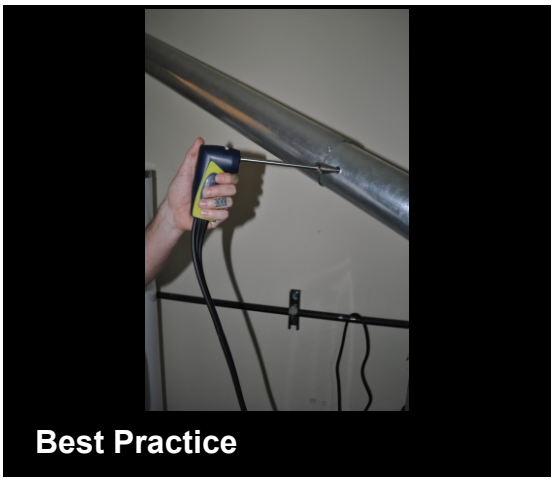
5.3003.15g - Carbon dioxide (CO2)and oxygen (O2)

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



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

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.

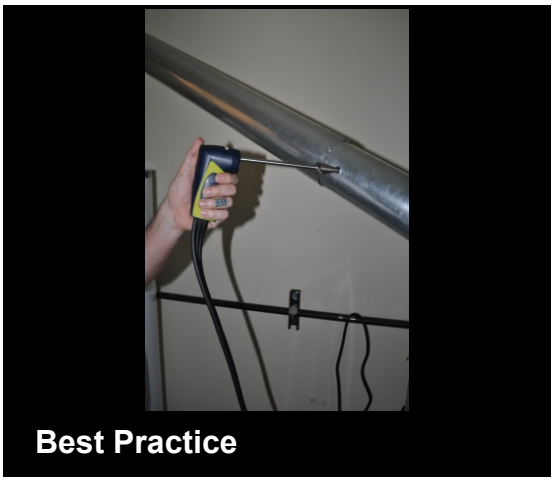
5.3003.15h - Excess combustion air

Desired Outcome:
Analysis of critical components and operations completed to industry and manufacturer specifications

Specification(s):
Excess air will be minimized in accordance with industry best practices

Objective(s):
Ensure equipment:

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



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

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

Tools:

1. Combustion analyzer with probe
2. Drill

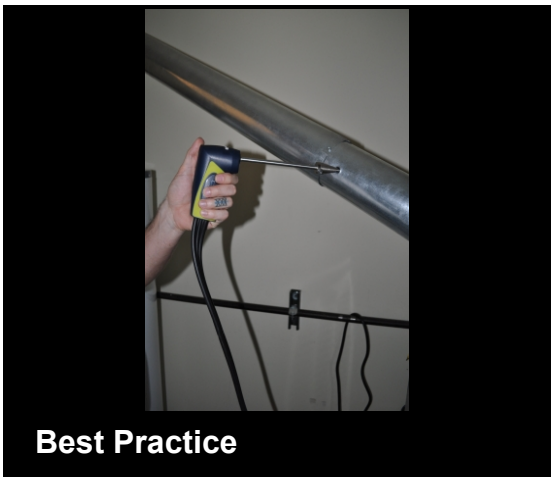
5.3003.15i - CO in flue gas

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 400 ppm air-free

Objective(s):
Ensure equipment:

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



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

CO should measure less than 400ppm

Tools:

1. Combustion analyzer with probe
2. Drill

5.3003.15j - Testing/inspection holes

Desired Outcome:
Analysis of critical components and operations completed to industry and manufacturer specifications

Specification(s):
All testing and inspection holes will be sealed as approved by the authority having jurisdiction

Objective(s):
Ensure equipment:

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

Before

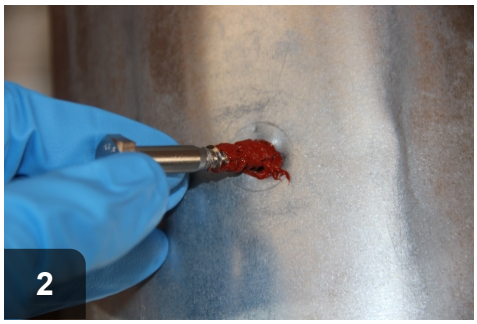
The testing hole was left unsealed.

After

The hole in both walls has been properly sealed with a plug, cap, or other approved method.

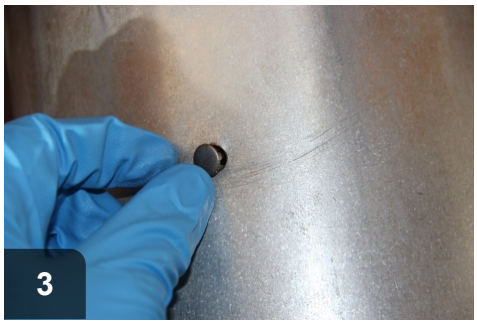
1

If using a bolt, apply high temperature sealant to the bolt, so that both holes will be sealed.



2

Screw the bolt into place, ensuring a proper seal on both pipes.



3

If sealing each wall individually, insert the plug into each hole.

4

Apply high temperature sealant to the perimeter of the plug.

6.6002.4 - Ducts (Exhaust Fans)

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

Note:

6.6002.4a - Duct design and configuration

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

Specification(s):
Consideration will be given to:

- Vent termination location
- Amount of space for duct run
- Roof condition, type, and access (e.g., metal, shingle, bow string, flat)
- Duct insulation

When applicable, pitch duct to remove condensation to outdoors

Ducts will be as straight as possible, fully extended, and have the shortest run possible

Turns will be made so the radius at the centerline is no less than one duct diameter

Duct diameter will be equal to or greater than the exhaust fan outlet

Fan flow will be verified by flow measurement to meet ASHRAE Standard 62.2

Objective(s):
Effectively move the required volume of air

6.6002.4b - Duct insulation

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

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

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

6.6002.4c - Duct support

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

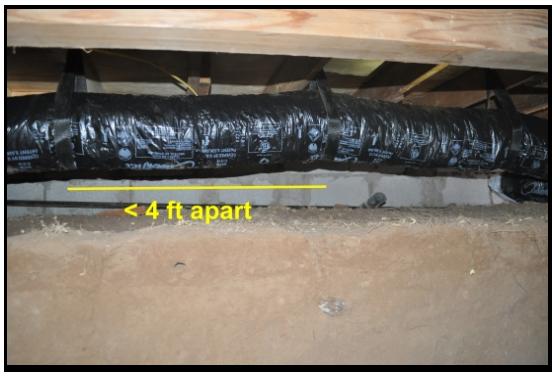
Supports with a width of at least 1 ½" will be used or adequate metal support

Objective(s):
Effectively move the required volume of air

Preserve the integrity of the duct system

Best Practice

Straps should be at least 1.5" wide.



Best Practice

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

Materials:

1. 1.5" webbing or strap material

6.6002.4d - Duct connections

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

In Progress

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

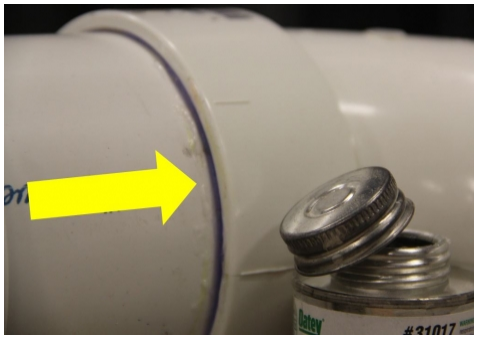
Tools:

1. drill
2. tie band tensioner

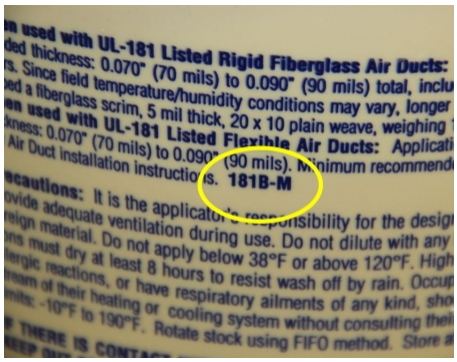
Materials:

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

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 - Duct materials

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

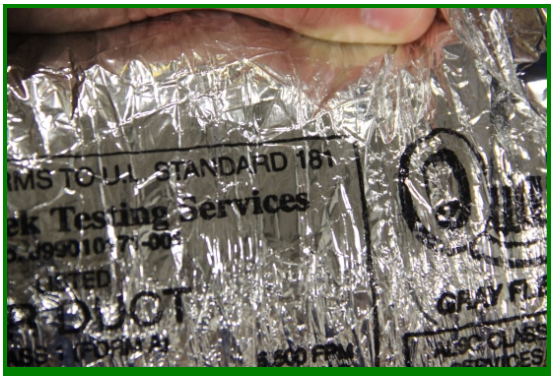
Rigid, smooth metal of 30-gauge wall thickness or thicker will be used

PVC material may be used

Objective(s):

Effectively move the required volume of air

Preserve the integrity of the duct system

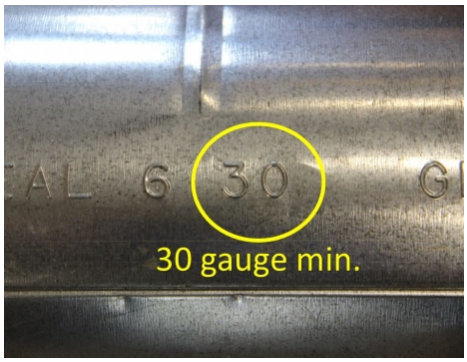


Best Practice

This material conforms to UL Standard 181.

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 - Total exhaust airflow

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

Best Practice

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.

6.6003.1 - Surface-Mounted Ducted

Desired Outcome:
Surface-mounted ducted fans installed to specification

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

6.6003.1a - Hole through interior surface

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

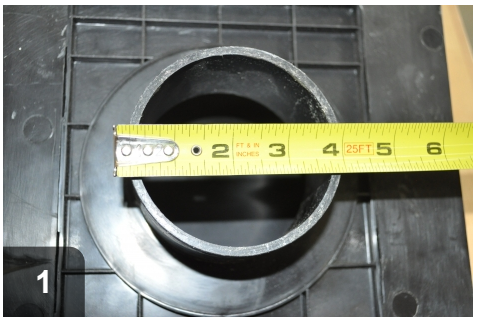
Determine size to cut hole by measuring fan assembly and ducting

After

A snug fit should be ensured to minimize weatherproofing required

Tools:

1. Tape measure
2. Saw
3. Writing utensil



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

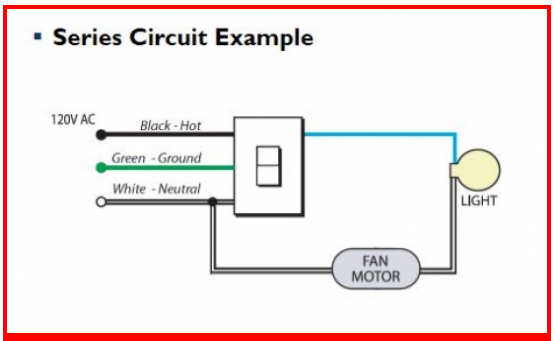
6.6003.1b - Wiring

Desired Outcome:
Surface-mounted ducted fans installed to specification

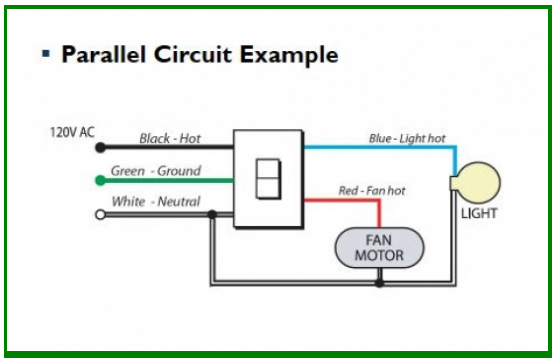
Specification(s):
Wiring will be installed by a properly licensed contractor, as required by the authority having jurisdiction

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



Before



After

6.6003.1c - Fan mounting

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

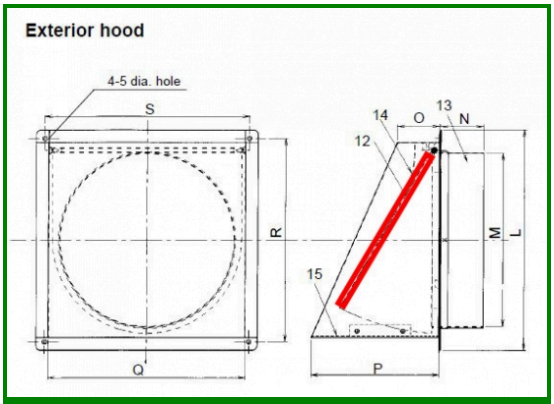
Best Practice

6.6003.1d - Backdraft damper

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



Best Practice

Damper should be installed to maintain exterior air barrier

6.6003.1e - Duct-to-fan connection

Desired Outcome:
Surface-mounted ducted fans installed to specification

Specification(s):
Duct-to-fan outlet will be connected and sealed as follows:

- Round metal-to-metal or metal-to-PVC connections will be fastened with a minimum of three equally spaced screws
- Other metal-to-metal or metal-to-PVC connections will be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, or tapes
- Flexible duct-to-metal or flexible duct-to-PVC 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 according to manufacturer specifications

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

Objective(s):

Exhaust to outside

Before

Fan duct is disconnected and venting into the attic space

After

Fan has been vented with sealed, insulated duct material

Tools:

1. Drill
2. Tie band tensioner
3. Brush

Materials:

1. Tie bands
2. Mechanical fasteners
3. UL181 listed mastic
4. PVC primer and cement
5. Insulated flex duct

Apply mastic to the connection fitting

Snug duct liner onto connection fitting

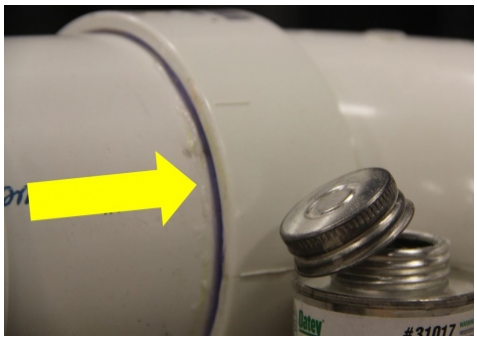
Use tie band and tensioner to secure liner to connection fitting

Apply mastic to fan connection

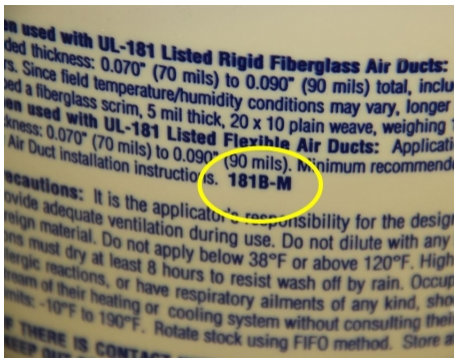
Using mechanical fasteners, secure connection fitting to fan connection

Snug insulation to fan housing and strap into place

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



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



Sealants should be UL181-M or UL181B-M listed

6.6003.1f - Fan housing seal

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

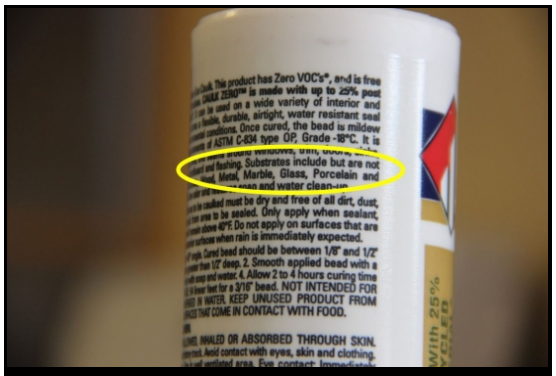
Objective(s):
Prevent air leakage through fan housing

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.



Best Practice

Sealant should be approved for its intended surfaces.

Tools:

1. caulk gun

Materials:

1. caulk

6.6003.1g - Fan to interior surface seal

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

Bad Practice

The opening for the fan is unsealed, allowing air leakage into or out of the attic.

Best Practice

The fan to interior surface seal is made using the proper materials and prevents airflow to and from the attic space.

6.6003.1h - Air flow

Desired Outcome:

Surface-mounted ducted fans installed to specification

Specification(s):

Air flows in cubic feet per minute (CFM) will be measured and adjusted to meet the whole house upgrade design requirements

Objective(s):

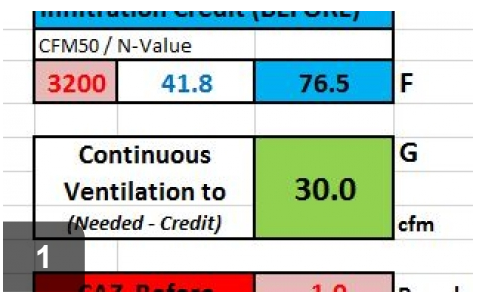
Exhaust sufficient air from desired locations to outside

In Progress

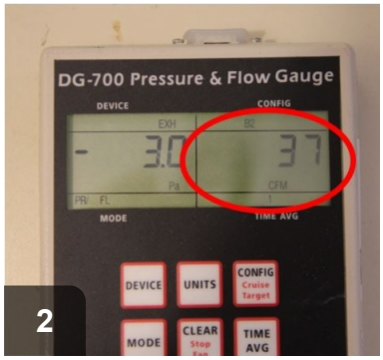
Exhaust fan flow should be measured and compared with the fans rated capacity as well as ASHRAE 62.2 requirements.

Tools:

1. digital manometer
2. exhaust fan flow measuring device
3. fan speed controller

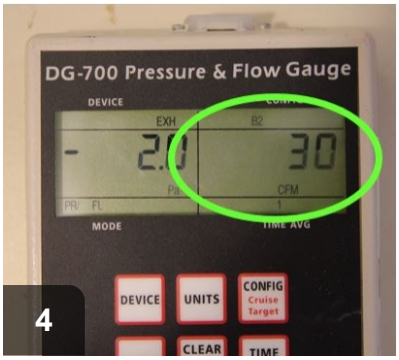


Perform the ASHRAE calculation to determine the Qfan or continuous ventilation needed.



Measure the fan flow to see how much adjustment is needed.

Adjust the fan speed using the chosen fan control device.



Re-measure the fan flow, and continue making adjustments until desired flow is achieved.

6.6003.1i - Preventing air leakage caused by exhaust fans

Desired Outcome:

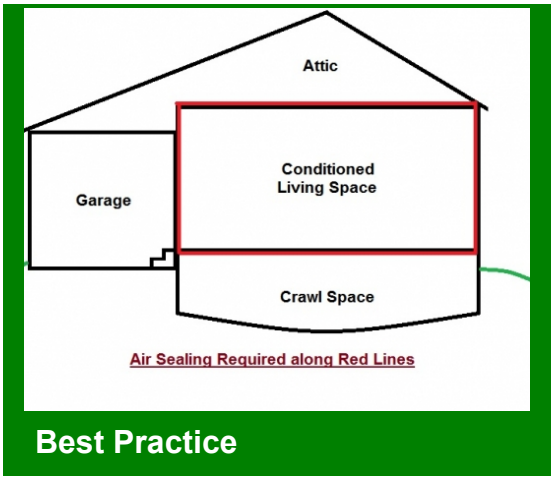
Surface-mounted ducted fans installed to specification

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

6.6003.1j - Combustion safety

Desired Outcome:
Surface-mounted ducted fans installed to specification

Specification(s):
Pressure effects will be assessed and corrected on all combustion appliances

Objective(s):
Ensure safe operation of combustion appliances

Before

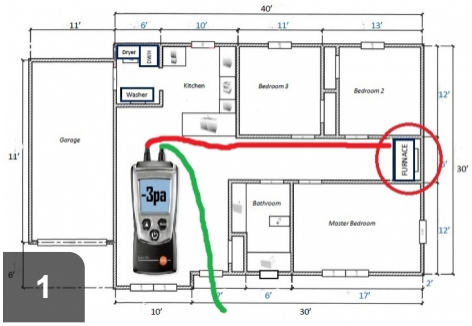
Installing new ventilation can cause imbalances within the house

After

Test that depressurization limit is not being exceeded by new ventilation

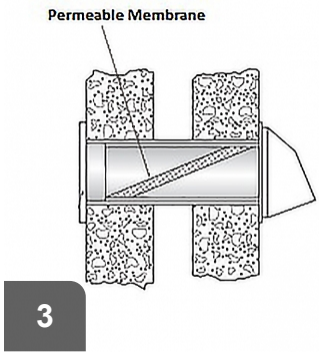
Tools:

1. Manometer



Run depressurization testing on house to ensure new ventilation isn't causing unsafe conditions

If depressurization limit is exceeded, mitigate to eliminate safety risk



Mitigate safety risk with make-up air or other pressure relief

After mitigation, verify that depressurization limits are not being exceeded

6.6003.2 - Inline

Desired Outcome:
Inline fans installed to specification

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

6.6003.2a - Wiring

Desired Outcome:
Inline 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

6.6003.2b - Access

Desired Outcome:
Inline fans installed to specification

Specification(s):
Fan and service switch will be accessible for maintenance according to NFPA 70 National Electric Code or local authority having jurisdiction

Objective(s):
Fan and service switch will be accessible for maintenance

6.6003.2c - Fan mounting

Desired Outcome:

Inline 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

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

Fan will be installed remotely by installing ducting from intake grille

Objective(s):
Ensure short duct run to achieve optimum air flow

Ensure fan is installed securely

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

Minimize noise

6.6003.2d - Backdraft damper

Desired Outcome:
Inline 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

6.6003.2e - Duct connections

Desired Outcome:
Inline fans installed to specification

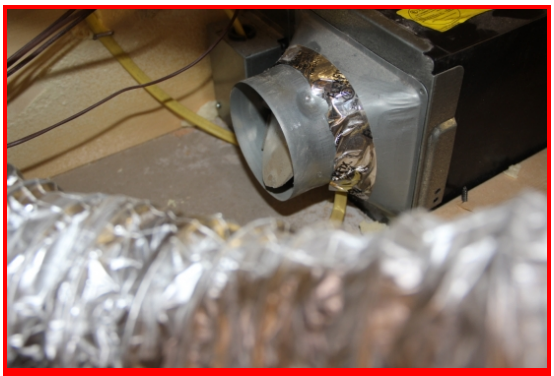
Specification(s):
Ducts will be connected and sealed to the intake fan and termination fitting as follows:

- Round metal-to-metal or metal-to-PVC connections will be fastened with a minimum of three equally spaced screws
- Other metal-to-metal or metal-to-PVC connections will be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes
- Flexible duct-to-metal or flexible duct-to-PVC 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):

Exhaust from desired location to outside

Preserve integrity of the duct system and building envelope



Before

Fan duct is disconnected and venting into the attic space.

After

Fan has been vented with sealed, insulated duct material

Tools:

1. Drill
2. Tie band tensioner
3. Brush

Materials:

1. Tie bands
2. Insulated flex duct
3. Mastic (air duct sealant) labeled UL 181 B-M
4. PVC primer
5. PVC cement

Apply mastic to the connection fitting

Snug duct liner onto connection fitting

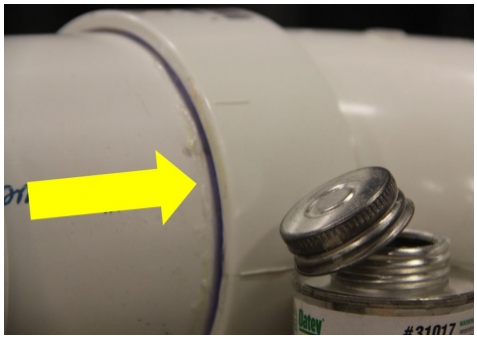
Use tie band and tensioner to secure liner to connection fitting

Apply mastic to fan connection

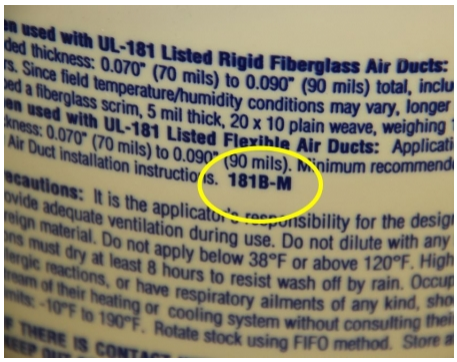
Using mechanical fasteners, secure connection fitting to fan connection

Snug insulation to fan housing and strap into place

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



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



Sealants should be UL181-M or UL181B-M listed

6.6003.2f - Boot to interior surface seal

Desired Outcome:

Inline fans installed to specification

Specification(s):

Sealants will be compatible with their intended surfaces

Sealants will be continuous and meet fire barrier specifications

Objective(s):
Prevent air leakage around intake housing

Prevent a fire hazard

6.6003.2g - Air flow

Desired Outcome:
Inline fans installed to specification

Specification(s):
Air flows in CFM will be measured and adjusted to meet the design requirements

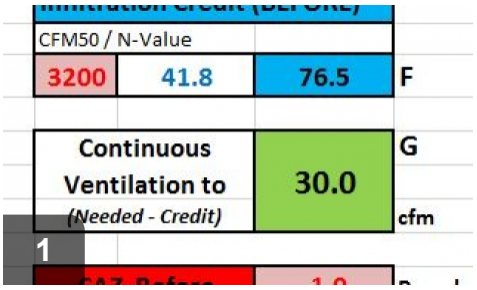
Objective(s):
Exhaust sufficient air from desired locations to outside

In Progress

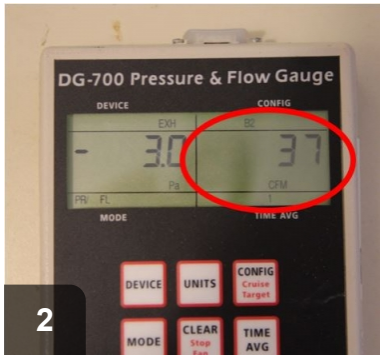
Exhaust fan flow should be measured and compared with the fans rated capacity as well as ASHRAE 62.2 requirements.

Tools:

1. digital manometer
2. exhaust fan flow measuring device
3. fan speed controller

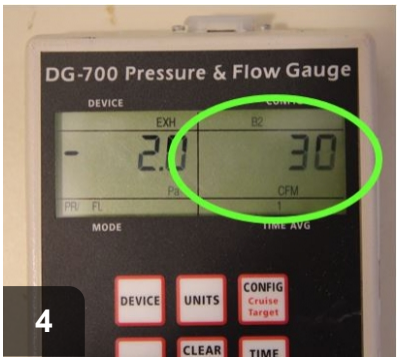


Perform the ASHRAE calculation to determine the Qfan or continuous ventilation needed.



Measure the fan flow to see how much adjustment is needed.

Adjust the fan speed using the chosen fan control device.



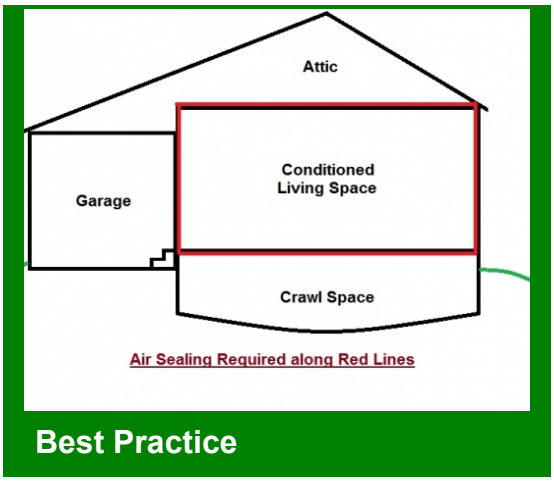
Re-measure the fan flow, and continue making adjustments until desired flow is achieved.

6.6003.2h - Preventing air leakage caused by exhaust fans

Desired Outcome:
Inline 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

6.6003.2i - Combustion safety

Desired Outcome:
Inline fans installed to specification

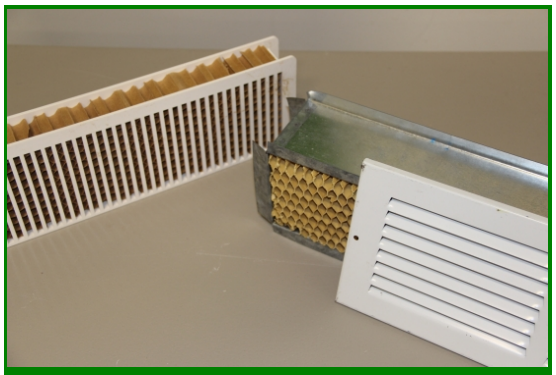
Specification(s):
Pressure effects caused by fans will be assessed and corrected when found outside of combustion safety standards

Exhaust fans and other exhausting systems shall be provided with makeup air or other pressure relief

Objective(s):
Ensure safe operation of combustion appliances

In Progress

Pressure should be measured in the CAZ to verify combustion appliances operate safely.

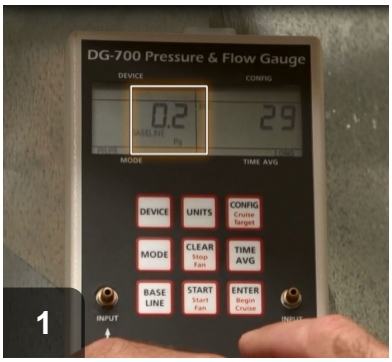


Best Practice

If depressurization in the CAZ exceeds acceptable limits, return air pathways or make up air may be needed.

Tools:

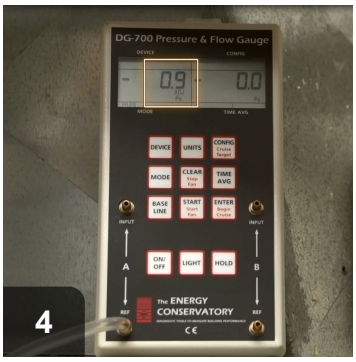
1. digital manometer
2. static pressure probe
3. 1/4" hoses
4. smoke stick or equivalent
5. combustion analyzer



Set the house to natural conditions. With the manometer measuring CAZ WRT outside, perform the baseline procedure.

Turn on all exhausting appliances(vented outdoors), including the dryer, kitchen fan, and bath fans.

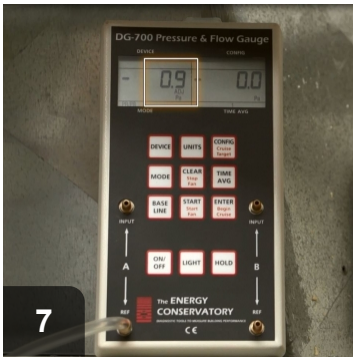
Close all doors. With your back to the CAZ, smoke doors with fans behind them. Smoke in:open door, smoke out:close it.



Measure CAZ pressure with the door open and record the reading. Close the door and record the reading.

Turn on the air handler fan.

Recheck all door positions for worst case depressurization. Smoke hits your toes, leave the door closed.



Measure CAZ pressure with the door open then closed. Record the readings. Recreate the WCD, or the most negative seen.

Fire the unit and check draft pressure using the manometer or combustion analyzer.

Measure flue gases at steady state and record readings. Turn off the unit being tested per manufacturers instructions.

6.6003.5 - Garage Exhaust Fan

Desired Outcome:
Contaminants properly removed from house

6.6003.5a - System selection

Desired Outcome:
Contaminants properly removed from house

Specification(s):
Ventilation for garage will be exhaust only and provide a minimum installed capacity of 100 CFM of ventilation per vehicle bay and will vent directly outdoors

Garage exhaust fan will be wired for continuous operation or installed with automatic controls that activate the fan whenever the garage is occupied and for at least 15 minutes after the garage has been vacated

If a ducted fan (not through-the-wall) is used, measure and verify the minimum air flow and adjust as necessary

Objective(s):
Remove contaminants from garage

Reduce contaminant migration from garage to house

Ensure occupant health and safety

6.6003.5b - Air leakage

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

The reading is zero indicating strong connection with the garage.

The reading is closer to 50, indicating the garage is connected to the outside.

Tools:

1. blower door assembly
2. manometer

Depressurize the house to 50 pascals.

The reading of 50 pascals indicates the zone is more closely connected to the outside.

6.6003.5c - Combustion safety

Desired Outcome:
Contaminants properly removed from house

Specification(s):
Pressure effects caused by fans will be assessed and corrected when found outside of combustion safety standards

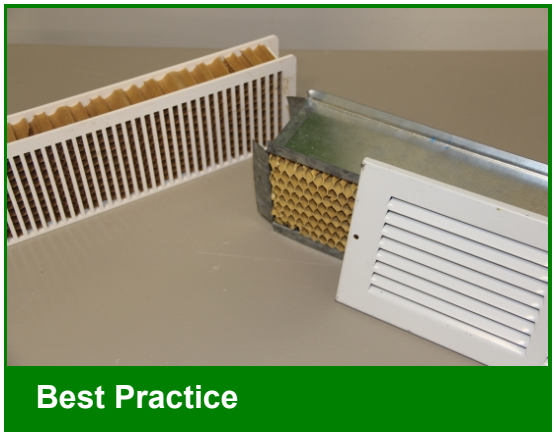
Exhaust fans and other exhausting systems shall be provided with makeup air or other pressure relief

Objective(s):

Ensure safe operation of combustion appliances

Ensure occupant health and safety

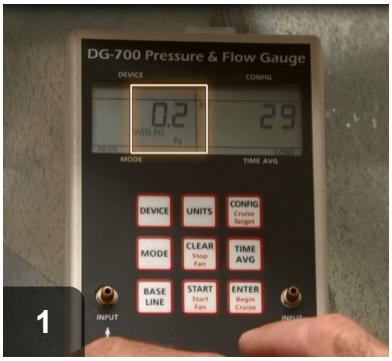
Pressure should be measured in the CAZ to verify combustion appliances operate safely.



If depressurization in the CAZ exceeds acceptable limits, return air pathways or make up air may be needed.

Tools:

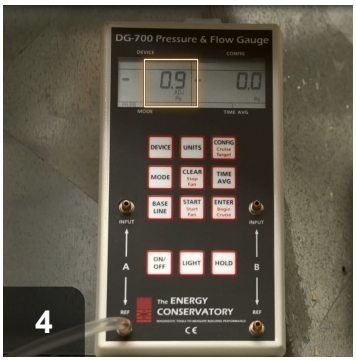
1. Manometer
2. Static pressure probe
3. 1/4" hoses
4. Smoke pencil
5. Combustion analyzer



Set the house to natural conditions. With the manometer measuring CAZ WRT outside, perform the baseline procedure.

Turn on all exhausting appliances(vented outdoors), including the dryer, kitchen fan, and bath fans.

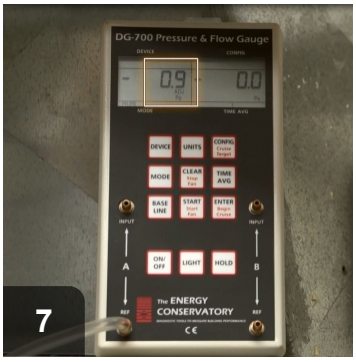
Close all doors. With your back to the CAZ, smoke doors with fans behind them. Smoke in:open door, smoke out:close it.



Measure CAZ pressure with the door open and record the reading. Close the door and record the reading

Turn on the air handler fan

Recheck all door positions for worst case depressurization. Smoke hits your toes, leave the door closed.



Measure CAZ pressure with the door open then closed. Record the readings. Recreate the WCD, or the most negative seen.

Fire the unit and check draft pressure using the manometer or combustion analyzer

Measure flue gases at steady state and record readings. Turn off the unit being tested per manufacturers instructions.

6.6003.6 - Fan Placement (Whole House/Common Space Exhaust Only)

Desired Outcome:
Provide primary ventilation for common spaces

Note:

6.6003.6a - Clearance

Desired Outcome:
Provide primary ventilation for common spaces

Specification(s):
Clearance for size of the fan recommended will be determined

Consideration will be given for adequate head clearance

Objective(s):
Ensure access for installation, operation, and maintenance

Ensure occupant safety

6.6003.6b - Power source

Desired Outcome:
Provide primary ventilation for common spaces

Specification(s):
Power source load will be determined as adequate

Consideration will be given to power source location

Objective(s):
Provide accessible and adequate power source

6.6003.6c - Location

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

Objective(s):
Allow fresh air distribution to common areas

6.6003.6d - Duct/vent

Desired Outcome:
Provide primary ventilation for common spaces

Specification(s):
Consideration will be given to:

- Vent termination location
- Amount of space for duct run
- Roof condition and type (e.g., metal, shingle, bow string, flat)
- Duct insulation

When applicable, pitch duct to remove condensation to outdoors

Ducts will be as straight as possible, fully extended, and have the shortest run possible

To the extent possible, turns will be made so that the radius at the centerline is no less than one duct diameter

Duct diameter will be equal to or greater than the exhaust fan outlet

Fan flow will be verified by flow measurement to meet ASHRAE standard 62.2

Objective(s):
Effectively move the required volume of air

6.6003.6e - Attachment

Desired Outcome:
Provide primary ventilation for common spaces

Specification(s):
Fan will be secured to a structural component

Structural integrity of the manufactured home will be maintained (e.g., roof trusses, walls, floor joists)

Objective(s):
Maintain structural integrity

Maintain fan attachment

6.6003.6f - Total exhaust airflow

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.

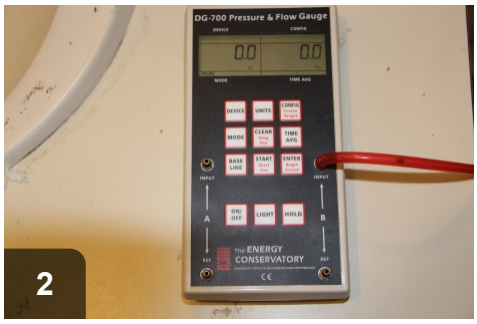
Tools:

1. Exhaust fan flow meter
2. Manometer

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

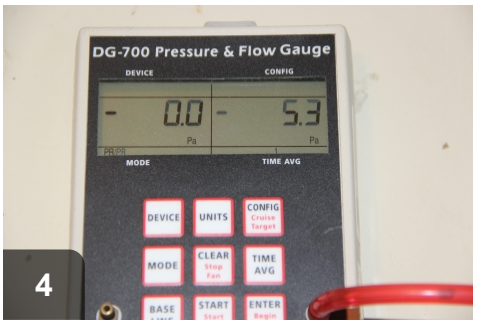
The requirements for kitchen range hoods are: 100CFM intermittent, or 5ACH(for kitchen area) continuous.

Attach hose to the fan meter.

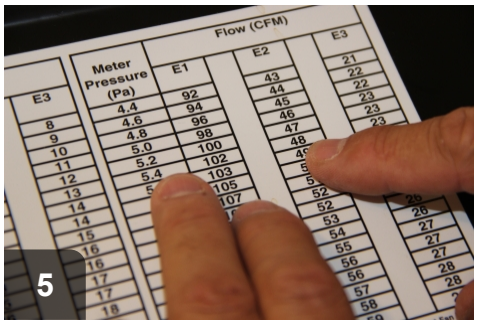


Attach hose to the manometer set to PR/PR.

Adjust gate on the flow meter as needed.



With the flow meter in place, read the resulting pressure on the manometer.



Match the pressure reading to the gate selection and read the final CFM flow.

6.6005.1 - Clothes Dryer

Desired Outcome:
Dryer air exhausted efficiently and safely

6.6005.1a - Clothes dryer ducting

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, except where allowed by the authority having jurisdiction

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

Dryer is vented outside, but with wrong material

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

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 - Termination fitting

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

Termination fittings for dryers should have backdraft dampers

Most modern dryer vents have a built-in backdraft damper

To minimize pest intrusion, mesh >1/4" square can be used

6.6005.1c - Makeup air

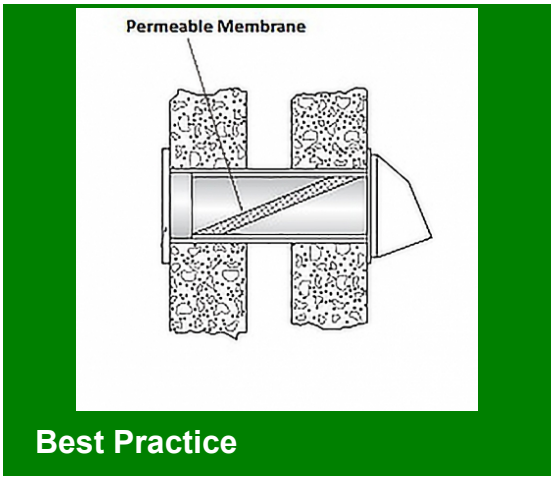
Desired Outcome:
Dryer air exhausted efficiently and safely

Specification(s):
If natural draft combustion appliances are present and if worst-case CAZ and/or other performance based testing is conducted and indicates a need for make-up air, make-up air will be provided in accordance with the current version of ASHRAE 62.2 and in compliance with the authority having jurisdiction.

If natural draft combustion appliances are present and if no performance based testing is conducted, make-up air will be provided prescriptively in accordance with the current version of ASHRAE 62.2 and in compliance with the authority having jurisdiction.

Objective(s):
Preserve integrity of building envelope

Effectively move air from clothes dryer to outside



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 - Combustion safety

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

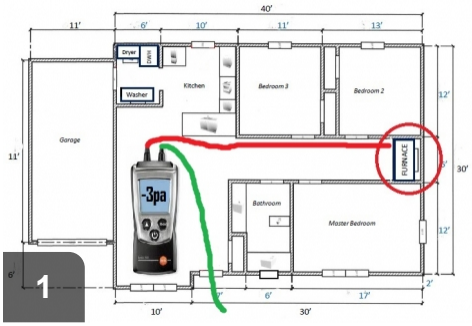
Ensure occupant health and safety

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

Test to verify combustion appliances are within depressurization limits

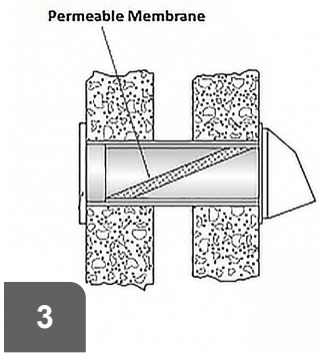
Tools:

1. Manometer



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 - Occupant education

Desired Outcome:
Dryer air exhausted efficiently and safely

Specification(s):
Occupant will be instructed to keep lint filter and termination fitting clean

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

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

Objective(s):
Effectively move air from clothes dryer to outside

Neglect of clothes dryer maintenance can cause fire hazards

Occupants should be taught to clean lint filters and termination fittings

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

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

6.6005.2 - Kitchen Range

Desired Outcome:
Kitchen range fan installed to specification

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

6.6005.2a - Wiring

Desired Outcome:
Kitchen range fan installed to specification

Specification(s):
Wiring will be installed in accordance with local regulations or the IRC in the absence of such regulations or where those regulations are not as stringent as the IRC

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

6.6005.2b - Fan venting

Desired Outcome:
Kitchen range fan installed to specification

Specification(s):
Kitchen range fans will be vented to the outdoors

Recirculating fans will not be used as a ventilating device

Objective(s):
Remove cooking contaminants from the house

Preserve integrity of building envelope

Before

Recirculating fans over ranges do not actually remove contaminants

After

Daylight visible through dampered kitchen exhaust proves venting access

6.6005.2c - Fan ducting

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

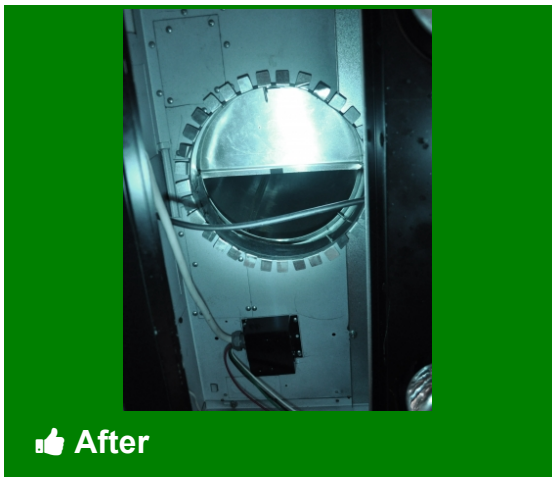
Ducting will be connected and sealed as follows:

- 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

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



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

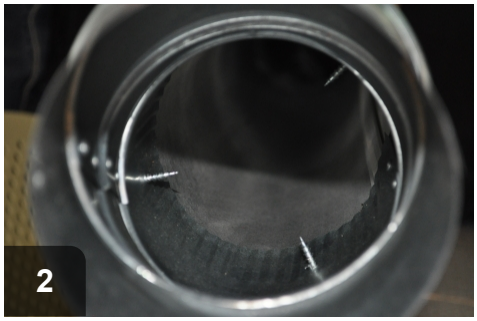
Materials:

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.

Duct run should be as smooth and short as possible



Duct should be fastened securely with three evenly-spaced screws

Then joints should be secured with fiberglass tape

Coat joint with UL-181 mastic, at least 0.08" (2mm) thick

Wrap duct with R-8 insulation. Seal seams in insulation vapor barrier with UL-181 listed foil or Mylar tape

6.6005.2d - Termination fitting

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 - Makeup air

Desired Outcome:
Kitchen range fan installed to specification

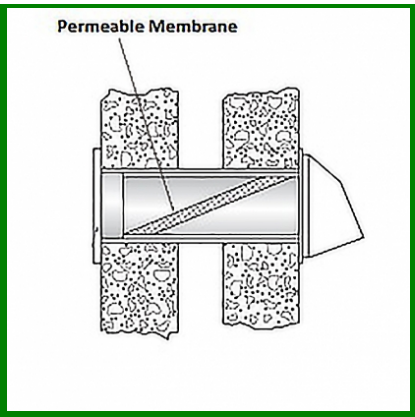
Specification(s):
Makeup air will be provided for kitchen range fans exhausting more than 200 CFM

Objective(s):
Ensure safe operation of combustion appliances

Ensure occupant health and safety

Before

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



After

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

6.6005.2f - Combustion safety

Desired Outcome:
Kitchen range fan installed to specification

Specification(s):
Pressure effects caused by fans will be assessed and corrected when found outside of combustion safety standards

Objective(s):

Ensure safe operation of combustion appliances

Ensure occupant health and safety

Before

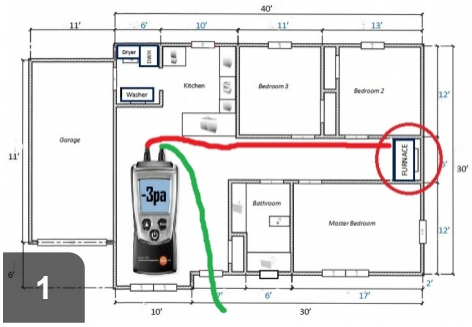
Kitchen exhaust fans can cause combustion appliances to depressurize

After

Test that combustion appliances are operating within depressurization limit

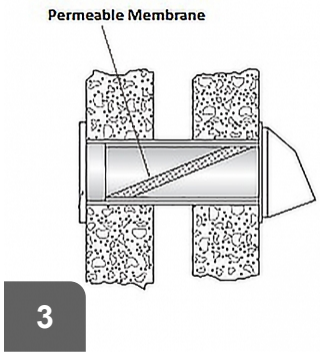
Tools:

1. Manometer



Run depressurization testing on house to ensure new ventilation isn't causing unsafe conditions

If appliances exceed depressuization limit, mitigate to reduce risk



Install a source of make-up air, such as a passive inlet vent

After mitigation, verify that depressurization limits are not being exceeded

6.6005.2g - Occupant education

Desired Outcome:
Kitchen range fan installed to specification

Specification(s):
Occupant will be instructed to keep grease filters and termination fitting clean

Objective(s):
Effectively move air from kitchen range to outdoors

6.6188.2 - Removing Supply Vents from Garages

Desired Outcome:
Safe removal of garage supply vents

Note:

6.6188.2a - Removal of supply/return in garage

Desired Outcome:
Safe removal of garage supply vents

Specification(s):
Supply run feeding the register will be truncated as near to the supply plenum as possible

If directly connected to the plenum, the supply run will be truncated at the plenum

If connected to a Y or T branch system, the supply run will be truncated at the Y or T

Return grille located in garage will be removed in the same manner as supply

Objective(s):
Minimize duct leakage

6.6188.2b - Patching of the hole in the duct system created by removal

Desired Outcome:
Safe removal of garage supply vents

Specification(s):
All holes in sheet metal ducts will be patched with sheet metal and secured with sufficient screws to hold the patch flat without gaps

Holes left in any Y or T will be capped with sheet metal caps and fastened with at least three screws

Objective(s):
Ensure a secure and strong patch

6.6188.2c - Sealing of the patch

Desired Outcome:
Safe removal of garage supply vents

Specification(s):
All patches will be sealed with mastic meeting UL 181 and in accordance with manufacturer specifications

Objective(s):
Ensure an airtight patch

6.6188.2d - Removal of discarded ducts

Desired Outcome:
Safe removal of garage supply vents

Specification(s):
All abandoned ductwork will be removed from work area

Objective(s):
Provide a clean work site

6.6188.2e - Patching of the register hole in garage

Desired Outcome:
Safe removal of garage supply vents

Specification(s):
Holes created by the removal of the register and boot will be patched and taped using material meeting local codes

Objective(s):
Prevent a fire hazard

6.6188.2f - External static pressure testing

Desired Outcome:

Safe removal of garage supply vents

Specification(s):
Units will be tested for external static pressure (ESP) before and after work

If there is a significant rise in ESP, air flow testing will be required

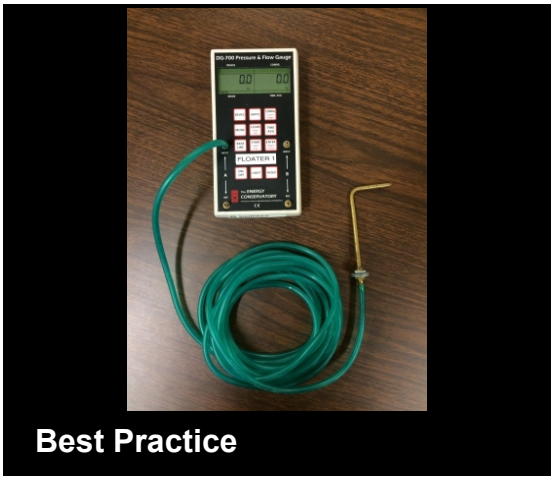
Objective(s):
Ensure correct fan performance

6.6188.2g - CAZ testing

Desired Outcome:
Safe removal of garage supply vents

Specification(s):
CAZ testing will be performed where combustion appliances are utilized

Objective(s):
Identify possible conditions that can cause unsafe equipment operating conditions



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

See SWS 2.0201.1 and SWS 2.0201.3 for CAZ testing

Tools:

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

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 2.0201.1 and 2.0201.3.

6.6205.1 - Manufactured Housing Exhaust-Only Strategies

Desired Outcome:
Provide primary ventilation for common spaces

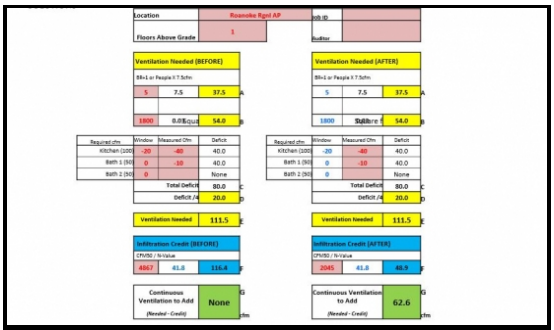
6.6205.1a - Assessment

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

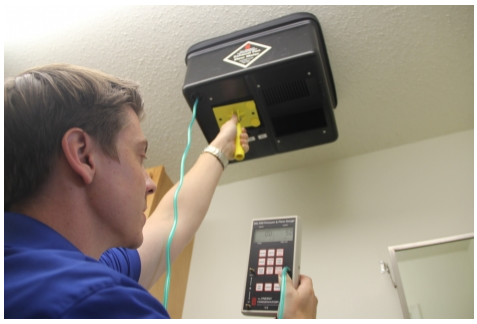
Objective(s):
Determine the ventilation needs of the whole house



In Progress

A calculation based on pre and post Wx numbers should be performed to determine the amount of ventilation needed.

The blower door number will be used to determine the infiltration credit.



Existing fan flow can be measured for alternate compliance, and new fans must be commissioned to ensure proper flow.

6.6205.1b - Selection

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

Best Practice

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)

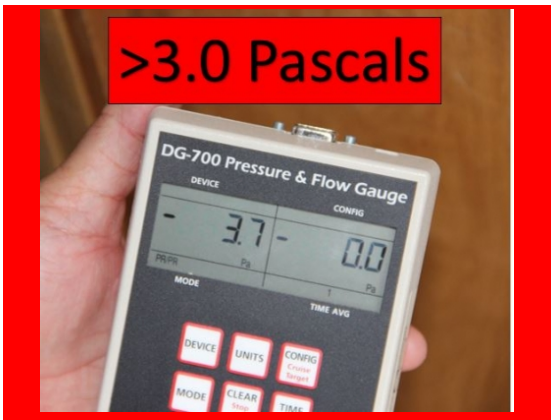
Best Practice

6.6205.1c - Location

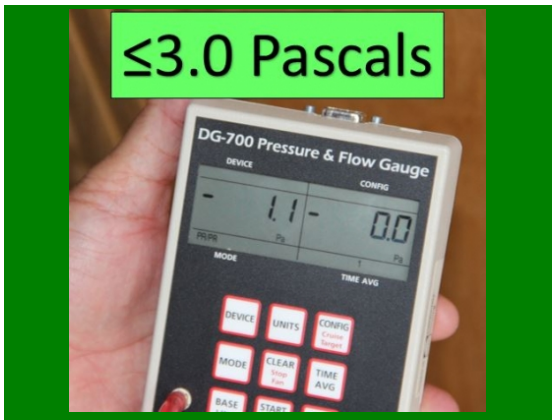
Desired Outcome:
Provide primary ventilation for common spaces

Specification(s):
No resistance greater than 3 pascals will exist between fan intake location with reference to the common area

Objective(s):
Ensure fresh air distribution to common areas



Before



After

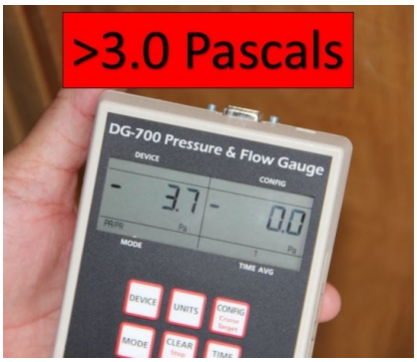
Tools:

1. digital manometer

Locate the fan in question.

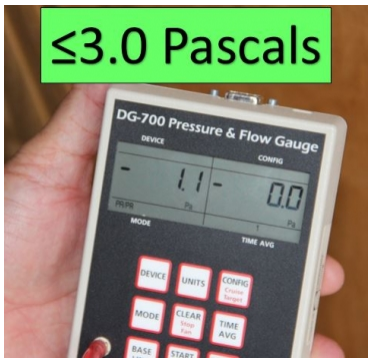
Connect a hose, and turn the manometer on to PR/PR.

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 - Climate considerations

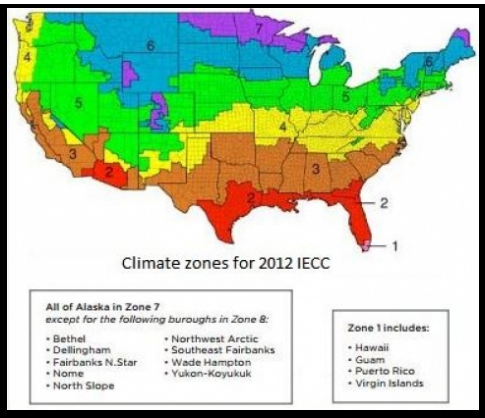
Desired Outcome:
Provide primary ventilation for common spaces

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.

6.6205.1e - Combustion Appliance Zone (CAZ) testing

Desired Outcome:

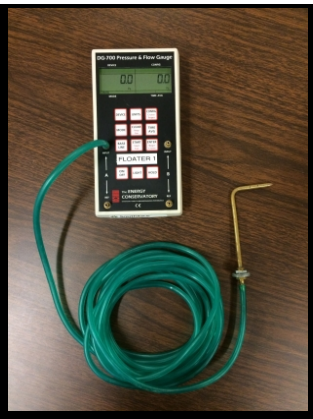
Provide primary ventilation for common spaces

Specification(s):

CAZ test will be performed where combustion appliances are utilized, where applicable

Objective(s):

Identify possible conditions that can cause unsafe equipment operating conditions



Best Practice

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

See SWS 2.0201.1 and SWS 2.0201.3 for CAZ testing

Tools:

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

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 2.0201.1 and 2.0201.3.

6.6205.1f - Occupant education

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

Best Practice

Clients should be educated on the purpose and operation of their new ventilation system.

Best Practice

Whole house ventilation should be clearly labeled.

6.6205.1g - Total exhaust airflow

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

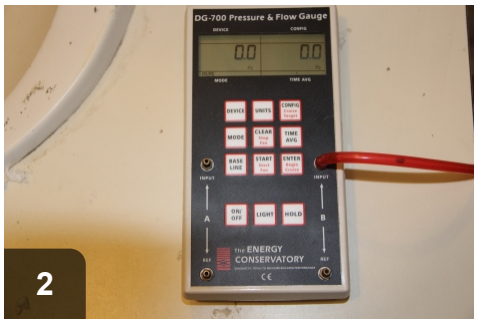
In Progress

Measure the fan flow with the flow meter.

Tools:

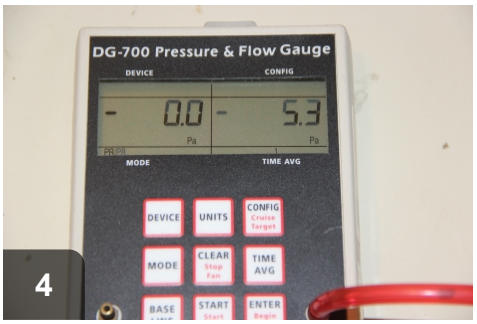
1. digital manometer
2. exhaust fan flow measuring device

Attach hose to the fan meter.

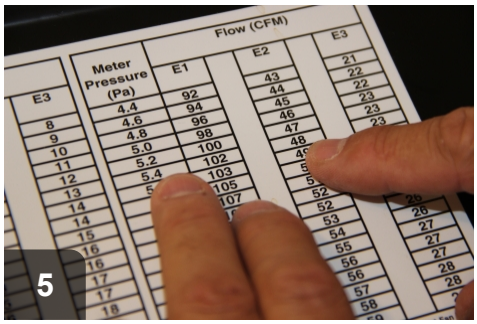


Attach hose to the manometer set to PR/PR.

Adjust gate on the flow meter as needed.



With the flow meter in place, read the resulting pressure on the manometer.



Match the pressure reading to the gate selection and read the final CFM flow.

6.6206.1 - Decommissioning Existing Exhaust or Supply Ventilation Systems

Desired Outcome:
Safely and properly eliminate fan

Note:

6.6206.1a - Power supply

Desired Outcome:
Safely and properly eliminate fan

Specification(s):
Power supply will be disconnected and properly terminated in visible junction box

Objective(s):
Safe removal of equipment

Ensure worker safety

6.6206.1b - Removal

Desired Outcome:
Safely and properly eliminate fan

Specification(s):
Fan components will be removed and disposed of lawfully

Duct work will be removed if necessary

OR

Fan housing will be left in place, ducts will be removed, and leakage points will be air sealed

Hole will be sealed and insulated to preserve the thermal and pressure boundary

Objective(s):
Remove fan

Preserve aesthetics, and thermal and pressure boundary

6.6206.1c - Repair

Desired Outcome:
Safely and properly eliminate fan

Specification(s):
Fan opening will be sealed and insulated

If necessary, the void from the duct work removal will be insulated

Fan termination will be sealed

Objective(s):
Maximize energy efficiency

Preserve the thermal and pressure boundary

6.6206.1d - Combustion Appliance Zone (CAZ) testing

Desired Outcome:
Safely and properly eliminate fan

Specification(s):
Combustion safety test will be performed where combustion appliances are utilized

Objective(s):
Identify possible conditions that can cause 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 pencil
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.

6.6288.2 - Sound Ratings—New Fan Installation

Desired Outcome:
Systems operate as quietly as possible

Note:

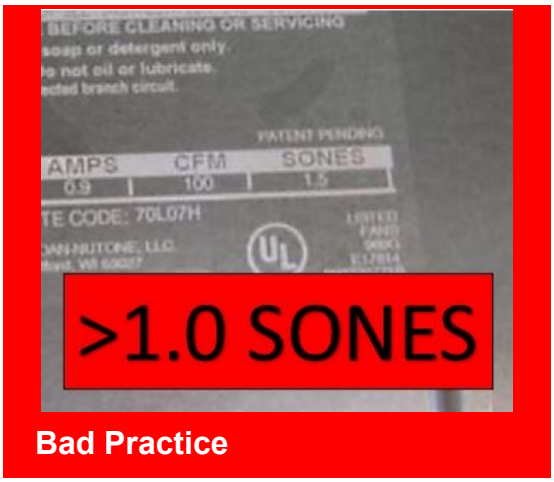
6.6288.2a - Primary ventilation system/continuously operating fan

Desired Outcome:
Systems operate as quietly as possible

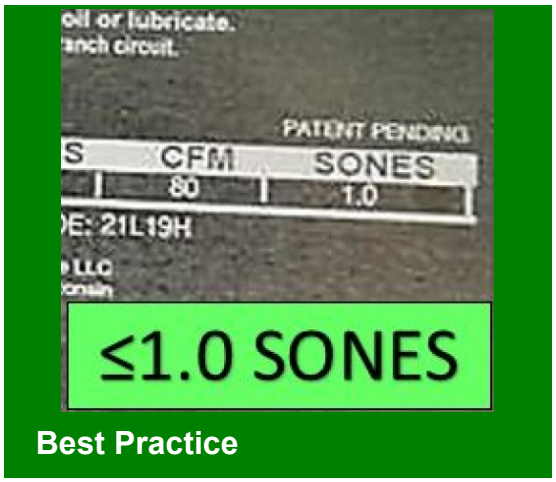
Specification(s):
System will be rated at a sound no greater than 1.0 sone

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 - Intermittent spot ventilation system

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

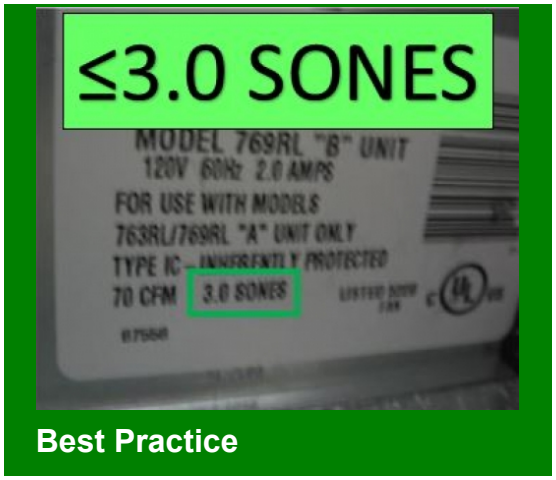
Objective(s):

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.

7.8101.1 - Shower Head and Faucet Aerator

Desired Outcome:
Energy and water use reduced while occupant needs for water flow maintained

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

7.8101.1a - Work assessment

Desired Outcome:
Energy and water use reduced while occupant needs for water flow maintained

Specification(s):
Installer pre-work assessment will be conducted to determine if plumbing needs correction before installing high-efficiency shower head or faucet

Objective(s):
Verify scope of work

7.8101.1b - Selection

Desired Outcome:
Energy and water use reduced while occupant needs for water flow maintained

Specification(s):
The rated flow of new shower heads will be 2.5 gallons per minute (GPM) or less

If multiple heads are provided, the total flow rate will not exceed 2.5 GPM

Aerator flow rate will be 2.2 GPM or less

Features will be selected that meet any special needs of the occupant (e.g., shut off, swivel, handheld showers)

Objective(s):
Reduce water and energy consumption

Ensure occupant satisfaction

7.8101.1c - Installation

Desired Outcome:
Energy and water use reduced while occupant needs for water flow maintained

Specification(s):
Equipment will be installed in accordance with manufacturer specifications and meet all applicable building codes

Water quality will be evaluated for debris that may clog the equipment

Once installed, high-efficiency shower heads or faucet aerators will be tested to determine if equipment is tightened adequately to prevent leakage at the point of connection

If needed, shower diverter will be repaired or replaced

Any penetrations to the exterior of the home created by the installation of the equipment will be sealed

Any damage done to the house during installation will be repaired

Specific information about proper maintenance of the equipment will be provided to the occupant

Warranty information, operation manuals, and installer contact information will be provided to the occupant

Water flow that satisfies the occupant will be provided by all shower heads and faucet aerators

Occupant's acceptance of the shower head and/or aerator will be documented

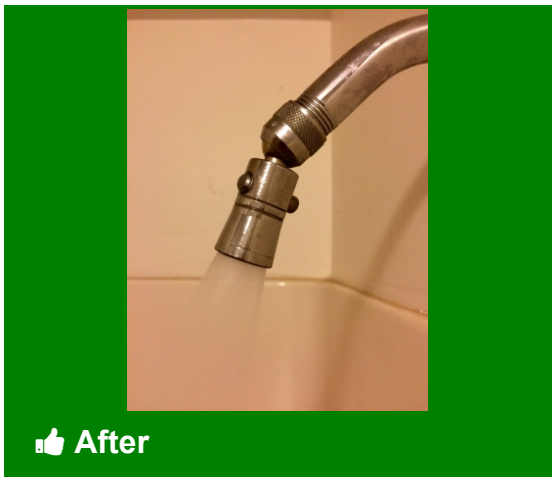
Objective(s):
Reduce water and energy consumption

Ensure occupant satisfaction with water flow

Eliminate water leakage

Prevent water damage

Old, high flow shower nozzle



Leak testing a new shower aerator

Tools:

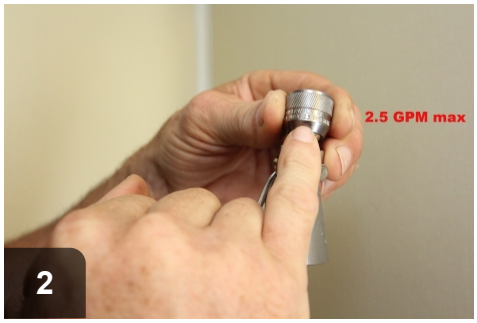
1. Tongue-and-groove pliers
2. Pipe wrench
3. Adjustable wrench

Materials:

1. Joint sealing tape
2. Rags

Interview occupant to document and verify their satisfaction with new shower and faucet aerators. Operate equipment after installation to ensure that it does not leak.

Remove old, high flow shower heads



Replace with 2.5 gpm maximum shower heads

Clean corrosion and old sealant from the threads on the shower nipple using a wire brush

Seal the threads on the shower nipple with two wraps of Teflon tape. Wrap tape clockwise so it won't peel off

Install the new low-flow shower head

Tighten the shower head using an adjustable wrench or tongue-and-groove pliers and a rag to protect the finish.

Turn on the water and check for leaks

Make sure the client is happy with their new low-flow shower head. Document approval with their signature in the file

7.8101.1d - Decommissioning

Desired Outcome:

Energy and water use reduced while occupant needs for water flow maintained

Specification(s):

Replaced shower heads and faucet aerators will be recycled or disposed of properly

Objective(s):

Prevent the reuse of inefficient equipment and components

Recycle or dispose of removed shower faucets and sink aerators to prevent their reuse.

7.8102.2 - Storage-Type Appliance

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

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

7.8102.2a - Hazardous material removal

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

Specification(s):
Health concerns in the removal and replacement of equipment (e.g., asbestos, other hazardous materials) will be identified

Written notification will be provided to occupants of the discovery of hazardous material, including contact information for regional EPA asbestos coordinator

Occupant will be asked to contract with an EPA-certified asbestos contractor to conduct abatement before equipment removal and replacement (occupant is responsible for abatement or remediation)

Objective(s):
Remediate health hazards using EPA- certified contractors

7.8102.2b - Equipment removal

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

Specification(s):
Accepted industry procedures and practices will be followed to:

- Remove old water heater and associated components in accordance with IRC or authority having jurisdiction

- Seal any unused chimney openings and penetrations in accordance with IRC or authority having jurisdiction
- Remove unused oil tank, lines, valves, and associated equipment in accordance with IRC or authority having jurisdiction

All work shall be completed by a licensed plumbing professional where required by the authority having jurisdiction and installed to industry-accepted standards

Objective(s):
Ensure the safety of the workers and occupants

Preserve integrity of the building

Remove old equipment in a timely and efficient manner

7.8102.2c - New equipment installation

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

Specification(s):
New water heater and associated components will be installed by a licensed contractor to accepted industry standards, in accordance with the IRC and manufacturer specifications

The system will be installed to be freeze resistant

Any existing water leaks will be repaired before installation begins

Any penetrations to the exterior of the home created by the installation of the equipment will be sealed

Objective(s):
Ensure the safety of the workers and occupants

Preserve integrity of the building

Remove old equipment in a timely and efficient manner

7.8102.2d - Emergency drain pan

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 in accordance with IRC

A ¾" drain line or larger will be connected to tapping on pan and terminated in accordance with IRC

Objective(s):
Collect and safely dispose of water escaping from the storage tank

7.8102.2e - Expansion tank

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

Specification(s):
Expansion tanks will be installed where required and in accordance with the AHJ

Objective(s):
Protect the storage tank from expansion

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

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.

7.8102.2f - Temperature and pressure relief valve

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 IRC and according to manufacturer specifications

Temperature and pressure relief valve discharge tube will be installed in accordance with IRC

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

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

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. Paraphrased from 2012 IRC P2803.6.1: 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.

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

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

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

7.8102.2g - Dielectric unions

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

Specification(s):
Dielectric unions will be installed in accordance with the IRC, authority having jurisdiction, and according to manufacturer specifications

Objective(s):
Break the stray voltage electrical circuit through the storage tank

7.8102.2h - Backflow prevention

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

Specification(s):
Backflow prevention will be installed in accordance with manufacturer specifications and all applicable codes

Objective(s):
Protect water supply from contamination

7.8102.2i - Thermal efficiency

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

If additional insulation is installed, it will be installed based on fuel type, making sure not to obstruct draft diverter, pressure relief valve, thermostats, hi-limit switch, plumbing pipes or elements, and thermostat access plates

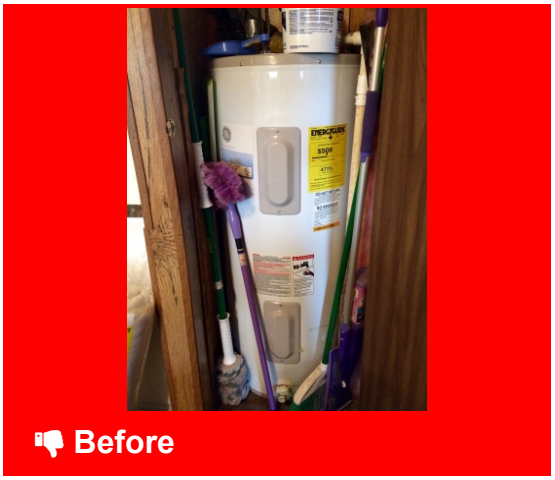
The first 6' of inlet and outlet piping will be insulated in accordance with manufacturer specifications

Combustible pipe insulation must maintain a minimum clearance of 6" from gas water heater draft hood and/or single wall metal pipe. Clearance from vent such as "B" vent should be maintained per vent manufacturer's specifications

Heat traps will be installed on the inlet and outlet piping where not provided by manufacturer

Objective(s):
Reduce standby loss from near tank piping and storage tank

Ensure insulation does not make contact with flue gas venting



Uninsulated storage-type water heater

Storage-type water heater with additional insulation

Tools:

1. Outward clinching (stitch) stapler
2. Utility knife
3. Scissors
4. Straight edge

Materials:

1. R-11 tank wrap
2. Vinyl tape
3. Staples
4. Rags or terry-cloth towels
5. Foam pipe insulation

Check warning labels on tanks. Not all water heaters may be insulated. Leave the tops of gas water heaters uninsulated, and be sure to keep combustion chamber access panels and combustion air holes uncovered. Cut out around thermostats on electric units. Use staples or zip ties to mechanically fasten insulation in place. Do not rely on tape alone to hold the tank wrap. Maintain proper clearance from gas appliance vents to combustibles.

Clean the entire outside of the water heater

Wrap blanket around tank and mark it where it overlaps. Add two or three inches and cut off using a straightedge and raz

Cut the insulation off at the mark. Peel away the excess insulation, leaving a flap of vapor barrier

Pull insulation blanket around the tank

Staple the flap to the blanket with outward clinching staples or use long zip ties to secure the blanket in place

Cut out around drain valve, P&T relief valve, and thermostats. Do not cover combustion access or air supply on gas units

Use remaining insulation for the top of electric water heaters. Tape up seams in the vapor barrier. Insulate water lines

7.8102.2j - Fuel supply

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

Specification(s):
Electric or fossil fuel supply components will be installed to accepted industry standards as per NFPA 31 and 54, or NFPA 70 National Electric Code (NEC) for electric components, or authority having jurisdiction

Objective(s):
Provide sufficient fuel to the water heater, burner, or element

7.8102.2k - Discharge temperature

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

Test temperature of hot water at faucets in house

Hot water temperatures should not exceed 120 degrees Fahrenheit

Adjust water heater settings and insulate as needed

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

7.8102.2l - Commissioning of system

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

Specification(s):
The following will be checked once the system has been filled and purged:

- Safety controls
- Combustion safety and efficiency
- Operational controls
- Fuel and water leaks
- Local code requirements

Commissioning will be in compliance with manufacturer specifications and relevant industry standards

Objective(s):
Ensure safe system function

Keep cost of ownership as low as possible

7.8102.2m - Occupant safety

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

Specification(s):
All homes will have a functioning CO alarm

If determined to be more than 5 years old, CO detector/alarm will be replaced

If CO levels in interior living spaces exceed outdoor levels, potential sources will be investigated and appropriate action taken to reduce them (e.g., have a qualified professional tune, repair, or replace improperly operating combustion appliances; apply weather stripping or conduct air sealing between the garage or crawl space and the home)

Objective(s):

Ensure occupant life safety; CO alarms are designed to detect levels at which occupants might become unable to evacuate

7.8102.2n - Occupant education

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

Specification(s):
Completed work will be reviewed

Occupants will be educated on the safe and efficient operation and maintenance of the system, including:

- Adjustment of water temperature and target temperature in accordance with local code
- Periodic drain and flush
- Expansion tank and backflow preventer (no occupant maintenance required)
- Periodic inspection, maintenance, or replacement

Objective(s):
Ensure occupant is informed of the safe, efficient operation and maintenance of the system

7.8102.3 - On-Demand Appliance

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

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

7.8102.3a - Hazardous material removal

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

Specification(s):
Health concerns in the removal and replacement of equipment (e.g., asbestos, other hazardous materials) will be identified

Written notification will be provided to occupants of the discovery of hazardous material, including contact information for regional EPA asbestos coordinator

Occupants will be asked to contract with an EPA-certified asbestos contractor to conduct abatement before equipment removal and replacement (occupant is responsible for abatement or remediation)

Objective(s):
Remediate health hazards using EPA- certified contractors

7.8102.3b - Equipment removal

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

Specification(s):
Accepted industry procedures and practices will be followed to:

- Remove old water heater and associated components in accordance with IRC
- Seal any unused chimney openings and penetrations in accordance with IRC

- Remove unused oil tank, lines, valves, and associated equipment in accordance with IRC

All work shall be completed by a licensed plumbing professional where required by the authority having jurisdiction and installed to industry-accepted standards

Objective(s):
Ensure the safety of the workers and occupants

Preserve integrity of the building

Remove old equipment in a timely and efficient manner

7.8102.3c - New equipment installation

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

Specification(s):
A new water heater and associated components will be installed to accepted industry standards, in accordance with the IRC, authority having jurisdiction, and manufacturer specifications

All work shall be completed by a licensed plumbing professional where required by the authority having jurisdiction

Objective(s):
Ensure the safety of the workers and occupants

Preserve integrity of the building

Remove old equipment in a timely and efficient manner

7.8102.3d - Emergency drain pan

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 and drain line shall be installed in accordance with the IRC

Objective(s):
Collect and safely dispose of water escaping from the storage tank

After

Emergency drain pan with drain piped to outside

Tools:

1. PVC cutters
2. Tongue-and-groove pliers

Materials:

1. 4" deep drain pan
2. 3/4" or 1" PVC drain fittings and pipe
3. PVC cement

7.8102.3e - Temperature and pressure relief valve

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 IRC and according to manufacturer specifications

Temperature and pressure relief valve discharge tube will be installed in accordance with IRC

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

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

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. Paraphrased from 2012 IRC P2803.6.1: 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.

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

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

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

7.8102.3f - Dielectric unions

Desired Outcome:

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

Specification(s):
Dielectric unions will be installed to accepted industry standards, in accordance with the IRC, and according to manufacturer specifications

Objective(s):
Break the stray voltage electrical circuit through the storage tank

7.8102.3g - Backflow prevention and pressure regulator

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

Specification(s):
Backflow prevention will be installed in accordance with manufacturer specifications

House water pressure and volume will be verified as sufficient to be in accordance with manufacturer specifications

All applicable codes will be followed

Objective(s):
Protect the water supply from contamination

Provide for sufficient volume and pressure

7.8102.3h - Thermal efficiency

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 meet IRC or local requirements, whichever is greater

Objective(s):
Reduce line losses

After

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 - Required combustion air

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 in accordance with IRC

If needed, additional combustion air will be provided in accordance with IRC

Objective(s):

Ensure adequate combustion air for operation of the appliance

Best practice is to install on-demand water heaters as direct-vent units

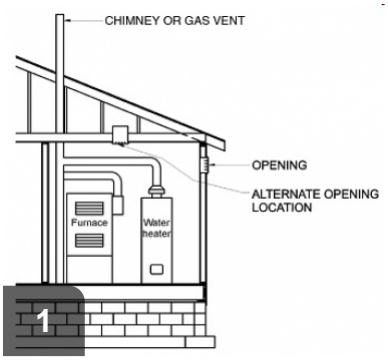
If not installed as direct vent, refer to notes and images on next page for required combustion air

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, in accordance with the 2012 IRC G2407.

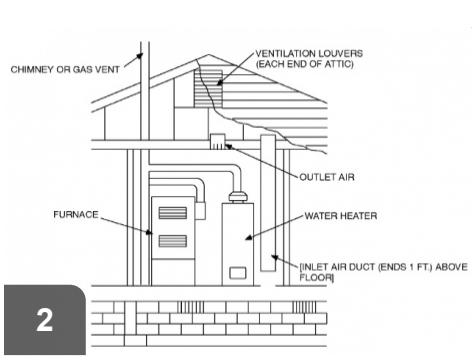
Image 1: For homes with one permanent opening, see 2012 IRC: G2407.6.2 (304.6.2): a minimum free area of 1 in2 per 3,000 Btu/h (734 mm2/kW) of total input rating of all appliances

Image 2: For homes with two permanent vertical duct openings, see 2012 IRC G2407.6.1 (304.6.1): a minimum free area of 1 in2 per 4,000 Btu/h (550 mm2/kW) of total input rating of all appliances

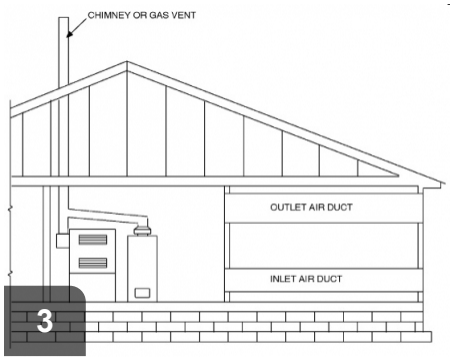
Image 3: For homes with two permanent horiztonal duct openings, see 2012 IRC G2407.6.1 (304.6.1): a minimum free area of 1 in2 per 2,000 Btu/h (1,100 mm2/kW) of total input rating of all appliances



min free area of 1 sqin per 3,000 Btu/h



min free area of 1 sqin per 4,000 Btu/



min free area of 1 sqin per 2,000 Btu/h

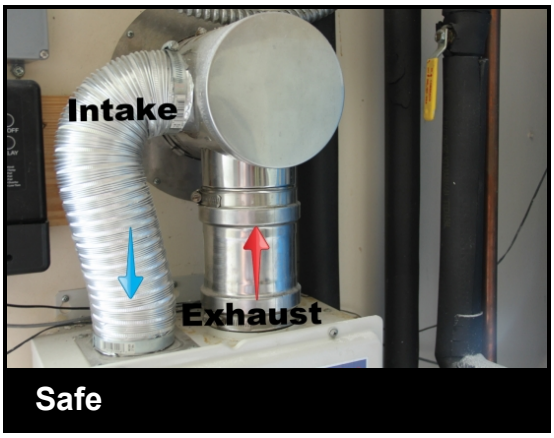
(734 mm2/kW) of total input rating h (550 mm2/kW) of total input rating (1100 mm2/kW) of total input rating

7.8102.3j - Venting of flue gases

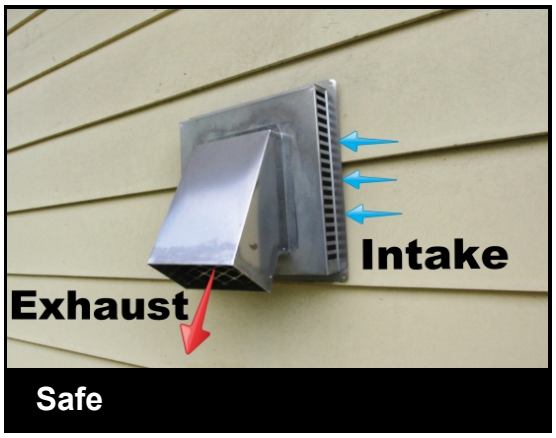
Desired Outcome:
Safe and reliable hot water source provided that meets occupant needs at lowest possible cost of ownership

Specification(s):
Combustion byproducts will be removed in accordance with IRC and manufacturer specifications

Objective(s):
Ensure the safety and durability of the venting system



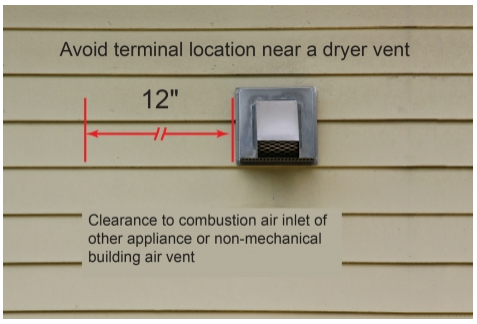
On-demand water heater combustion air intake and exhaust vent, interior view



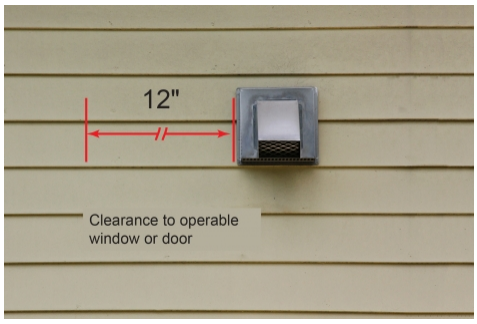
On-demand water heater combustion air intake and exhaust vent

Follow manufacturer's venting instructions for on-demand appliances. Local codes may be more stringent than the International Residential Code (Section G2407), whcih governs venting of gas appliances,

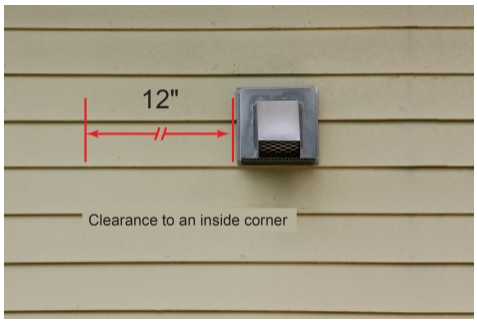
Do not locate vent terminals near dryer vents.



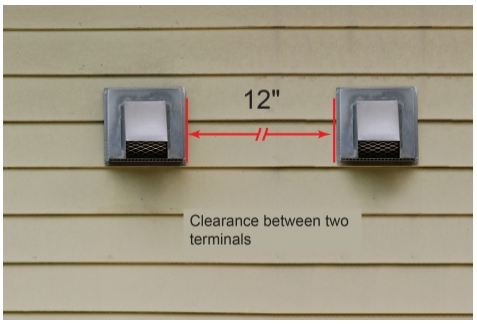
Leave 12" between a vent terminal and any non-mechanical building vent or combustion air inlet from another appliance



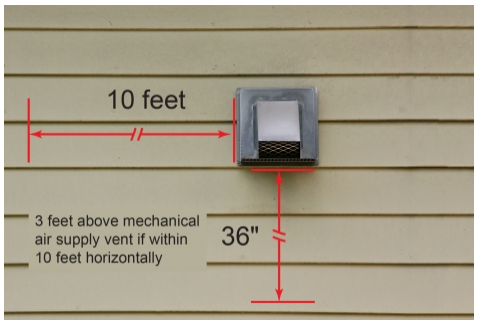
Leave 12" between vent terminals and any operable door or window



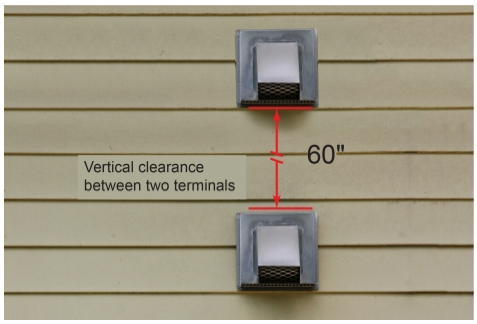
Allow 12" clearance from the edge of a vent to any inside corner of the building



Allow 12" between any two vent terminals

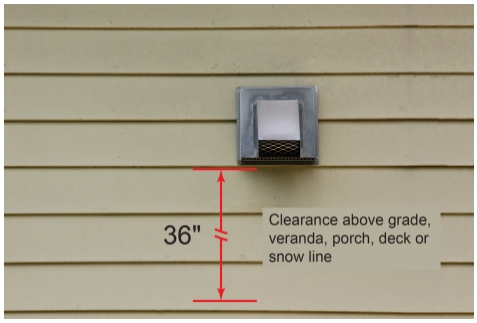


Install vent terminal at least 3 feet higher than any mechanical air inlet that is closer than 10 feet away horizontally



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 - Flue gas testing

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

If combustion is not in compliance with BPI-1100-T, 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.

Verify that calibration date is current on combustion analyzer

Test flue gases for carbon monoxide at outlet of vent

Verify that carbon monoxide levels are within specifications

7.8102.3l - Electric and fossil fuel supply

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

Specification(s):
Electric or fossil fuel supply components will be installed to accepted industry standards as per IRC, the NFGC, NFPA 31, 54, and 58 for gas and oil, or NFPA 70 National Electric Code for electric

Energy input required by the appliance will be in accordance with manufacturer specifications

Objective(s):
Provide sufficient fuel to the water heater burner or element

7.8102.3m - Cold water supply

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

Specification(s):
The volume and pressure of the water supplied to the appliance will be in accordance with manufacturer specifications

Objective(s):
Provide sufficient volume and pressure of water to the appliance

7.8102.3n - Discharge temperature

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 in accordance with manufacturer instructions and in compliance with local codes

Use extreme caution when temperature setting is above 120°F

Objective(s):
Ensure safe hot water supply temperature to fixtures

Hot water temperature over 120°F

Hot water temperature under 120°F

Tools:

1. Thermometer
2. Cup or bowl

Use a thermometer to measure hot water temperature. 120°F is the recommended setting

7.8102.3o - Commissioning of system

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

Specification(s):
The following will be checked once the system has been connected and filled:

- Safety controls
- Combustion safety and efficiency
- Operational controls
- Fuel and water leaks
- Cycle unit
- Local code requirements

Manufacturer specifications and all relevant industry standards will be met in commissioning

Objective(s):
Ensure system functions safely with lowest possible cost of ownership

7.8102.3p - Ambient CO

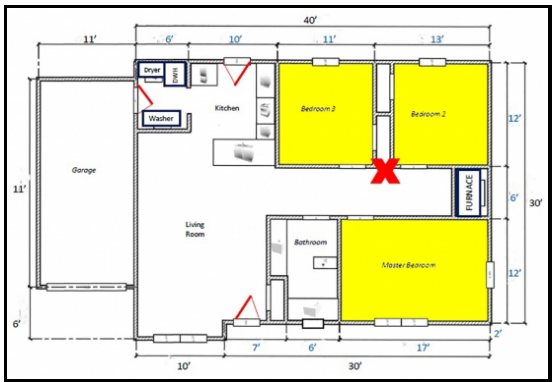
Desired Outcome:
Safe and reliable hot water source provided that meets occupant needs at lowest possible cost of ownership

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

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

Tools:

1. Drill/screwdriver

Materials:

1. CO alarm
2. Fasteners

7.8102.3q - Occupant education

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

Specification(s):
Completed work will be reviewed

Occupants will be educated on the safe and efficient operation and maintenance of the system, including:

- Adjustment of water temperature and target temperature in accordance with local code
- Operation of backflow preventer and pressure regulator (no occupant maintenance required)
- Importance of keeping operating manuals accessible

Objective(s):
Ensure occupant is informed of the safe, efficient operation and maintenance of the system

7.8103.1 - Storage-Type Appliance

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

7.8103.1a - Health and safety

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 - Visual inspection

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Inspection will be conducted to show compliance with the IRC, 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

Check draft diverter alignment

Inspect for rust, corrosion, and leaks

7.8103.1c - Thermal efficiency

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Water heater storage tanks shall have a minimum R-value of R-24

Added insulation will not obstruct the unit's draft diverter, pressure relief valve, thermostats, hi-limit switch, plumbing pipes or elements, and thermostat access plates

The first 6' of inlet and outlet piping will be insulated in accordance with IRC or local requirements,

whichever is greater

Objective(s):
Reduce standby losses from near tank piping and storage tank

Ensure insulation does not make contact with flue gas venting

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

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

Tools:

1. Scissors
2. Utility knife
3. Outward clinching staple gun

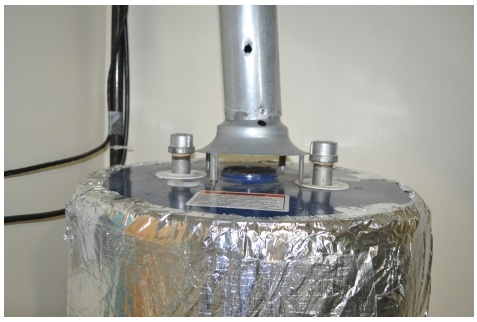
Materials:

1. Insulation blanket
2. Plastic zip ties
3. Tape
4. Staples

Determine the R-value of the existing water heater by A) searching the internet using the model number or B) measuring the thickness of the existing insulation and multiplying by 3.14 per inch for fiberglass or 6.25 per inch for foam. Add insulating wrap to achieve at least R-24. R-values may be added, so a tank with a factory-installed R-value of R-6 would need an additional R-18 to reach the desired value of R-24.

Maintain 2" clearance between insulation and the draft diverter. Cut out around thermostats, pressure relief valves, and other items listed in the specification.

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



Blanket does not obstruct draft diverter or plumbing pipes and elements

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

Data plate should still be accessible after wrapping

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

7.8103.1e - Temperature and pressure relief valve

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Correct temperature and pressure relief valve will be installed in compliance with IRC and according to manufacturer specifications

Temperature and pressure relief valve discharge tube will be installed in accordance with IRC

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

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

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. Paraphrased from 2012 IRC P2803.6.1: 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.

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

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

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

7.8103.1f - Maintenance records

Desired Outcome:

Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Occupants will be advised to keep records of all maintenance done to their system

Copies of or access to installation and operation manuals will be provided

Objective(s):
Provide a history of system installation and maintenance to improve chance of successful future maintenance or repair

7.8103.1g - Occupant safety

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Carbon monoxide (CO) alarms will be installed in each dwelling in accordance with ASHRAE 62.2 and authority having local jurisdiction

Occupant will be provided information regarding the health effects and risk of high CO concentrations as well as a list of monitors that can provide more detail regarding CO levels

Objective(s):
Ensure occupant life safety

Inform occupant regarding possible CO hazards

7.8103.1h - Occupant education

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Completed work will be reviewed

Occupants will be educated on the safe and efficient operation and maintenance of the system, including:

- Adjustment of water temperature and target temperature in accordance with local code
- Periodic drain and flush
- Periodic inspection, maintenance, or replacement of anode rod

Objective(s):

Ensure occupant is informed of the safe, efficient operation and maintenance of the system

7.8103.2 - On-Demand Appliance

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Note:
The authority having jurisdiction may require that a licensed professional perform certain tasks outlined in this detail.

7.8103.2a - Health and safety

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

On-demand water heater

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 - Visual inspection

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Inspection will be conducted to show compliance with the IRC, 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

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

7.8103.2c - Temperature and pressure relief valve

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Correct temperature and pressure relief valve will be installed in compliance with IRC and according to manufacturer specifications

Temperature and pressure relief valve discharge tube will be installed in accordance with IRC

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

Water heaters should be not capped off at T&P relief valve

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

Tools:

1. Pipe wrench
2. Hacksaw or tubing cutter
3. Propane or MAPP gas torch

Materials:

1. CPVC or copper piping and fittings
2. CPVC primer and cement
3. Flux, solder, and emery cloth for sweating copper fittings
4. Teflon tape or pipe thread sealing compound

Check local jurisdictional codes. Paraphrased from 2012 IRC P2803.6.1: 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.

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

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

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

7.8103.2d - Flue gas testing

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Undiluted flue gases will be checked with a calibrated combustion analyzer in accordance with BPI-1100-T

If combustion is not in compliance with BPI-1100-T, diagnostics and adjustments will be done to manufacturer specifications or local codes

Objective(s):
Perform combustion testing

Test flue gases at outlet of vent to verify carbon monoxide levels are within specifications

Tools:

1. Properly calibrated combustion analyzer

Verify that calibration date is current on combustion analyzer

Test flue gases for carbon monoxide at outlet of vent

Verify that carbon monoxide levels are within specifications

7.8103.2e - Required combustion air

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
If sealed combustion has not been installed:

- 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 will be 50 cubic feet per 1,000 Btu/h in accordance with 2012 IRC G2407.5.1
- If needed, additional combustion air will be provided in accordance with IRC

Objective(s):
Ensure adequate combustion air for operation of the appliance

Calculate available combustion air for natural draft appliances

See Notes and images on next page for required combustion air

Tools:

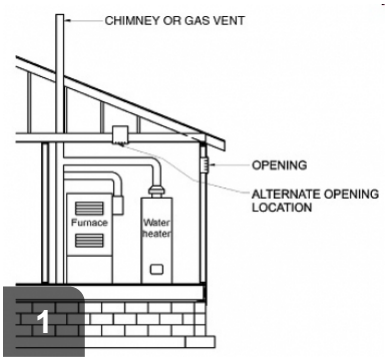
1. Calculator
2. Tape measure

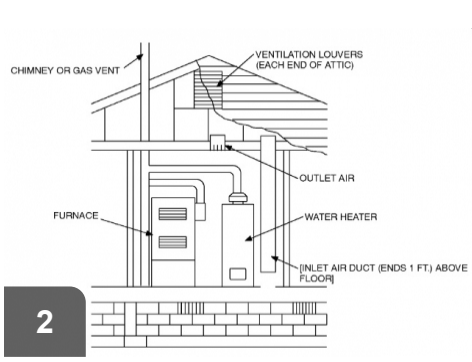
To determine adequate combustion air: add up the input Btus of all combustion appliances in the space and divide by 20. The result is the minimum required air volume in cubic feet (50 cubic feet per 1,000 input Btus). If the available volume is less than 50 cubic feet per 1,000 input Btus, provide additional combustion air as listed below for each circumstance, in accordance with the 2012 IRC G2407.

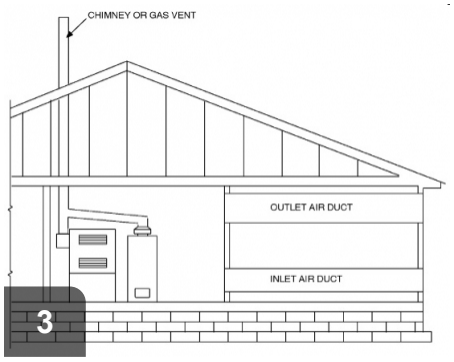
Image 1: For homes with one permanent opening, see 2012 IRC: G2407.6.2 (304.6.2): a minimum free area of 1 in2 per 3,000 Btu/h (734 mm2/kW) of total input rating of all appliances

Image 2: For homes with two permanent vertical duct openings, see 2012 IRC G2407.6.1 (304.6.1): 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 horiztonal duct openings, see 2012 IRC G2407.6.1 (304.6.1): a minimum free area of 1 in2 per 2,000 Btu/h (1,100 mm2/kW) of total input rating of all appliances







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

7.8103.2f - Venting of flue gases

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Condition of venting will be inspected in accordance with Section 504 IFGC, NFPA 54, or NFPA 58 for gas water heaters or NFPA 31 for oil water heaters, and authority having local jurisdiction

Objective(s):
Verify proper venting of flue gases

Inspect direct vents for proper connections, rust, corrosion, and clearances

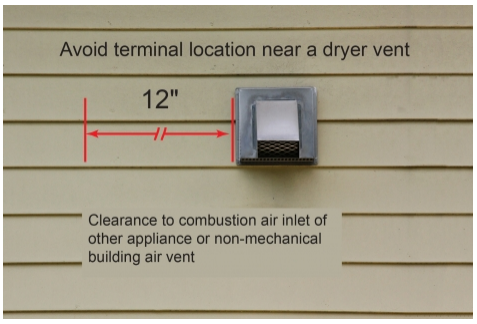
Inspect direct venting for proper connections, rust, corrosion, and clearances

Tools:

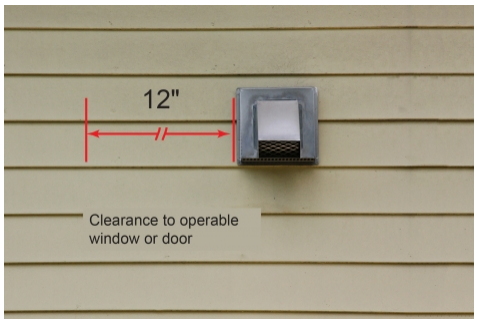
1. Flashlight
2. Inspection mirror

Check that all connections are secure, free of rust and corrosion, and that vents are made from the proper material. Verify that sealed combustion units are installed as direct vents, that is, with both combustion air intakes and exhaust gas vents connected.

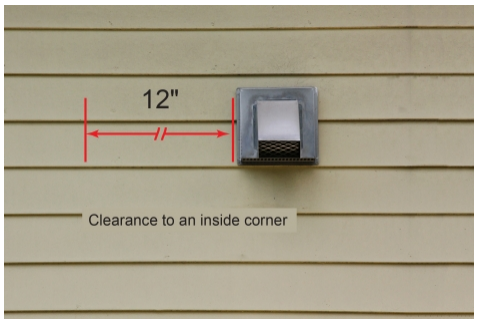
Check that terminal locations are in accordance with the IRC, Section G2407, manufacturer's instructions, and/or local codes.



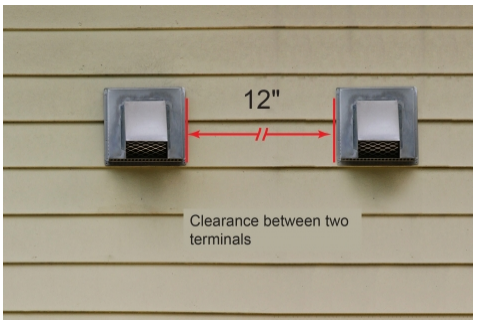
Verify12" between a vent terminal and any non-mechanical building vent or combustion air inlet from another appliance



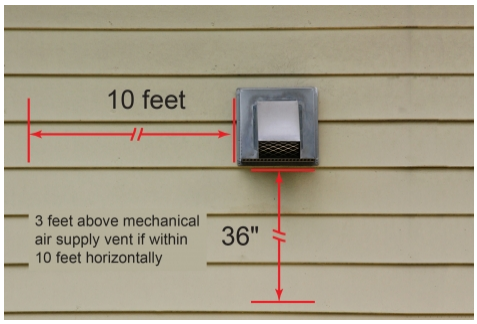
Check that there is 12" between vent terminals and any operable door or window



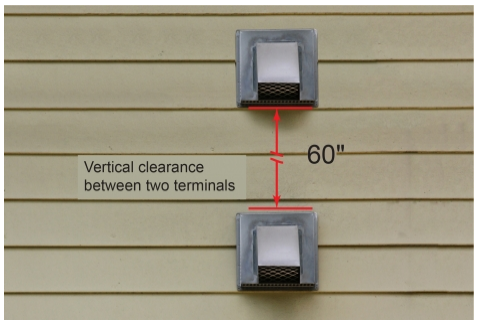
Ensure 12" clearance from the edge of a vent to any inside corner of the building



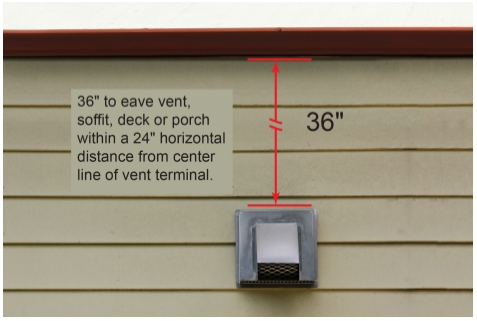
Verify 12" between any two vent terminals



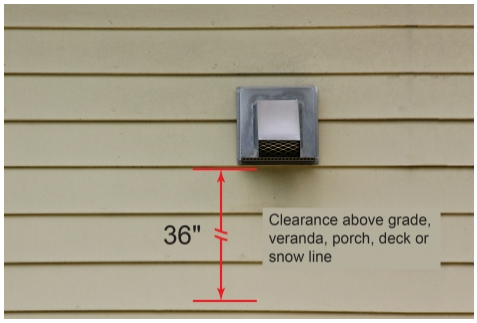
Verify vent terminals are least 3 feet higher than any mechanical air inlet closer than 10 feet away horizontally



Ensure there is 60" between terminals in line vertically



Verify vent terminals are 36" below any eave, soffit, porch, or deck within 24 horizontal inches of center of vent



Ensure that vents are at least 36" above grade, porch, deck, veranda, or snow line

7.8103.2g - Fuel supply

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

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

7.8103.2h - Cold water supply

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Water supplied to the appliance will be of sufficient volume and pressure to be in accordance with manufacturer specifications

Objective(s):
Verify sufficient volume and pressure of water to the appliance

Best Practice

Testing water supply pressure

Tools:

1. Water pressure gauge

Check manufacturer's specifications for flow and pressure requirements. System pressure may be easily measured with a pressure gauge attached to a hose bib or faucet. Pipe sizing calculations (to ensure adequate flow rates) are best left to a licensed plumber or mechanical contractor.

7.8103.2i - Discharge temperature

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Discharge temperature will be set not to exceed 120°F or in accordance with local code, whichever is lower

Objective(s):
Ensure safe hot water supply temperature to fixtures

Water heaters producing water over 120 degrees raise heating costs

Water heaters should produce water under 120 degrees to prevent scalding

Tools:

1. Thermometer

Test temperature of hot water at faucets in house

Hot water temperatures should not exceed 120 degrees Fahrenheit

Adjust water heater settings and insulate as needed

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

7.8103.2j - Test the system safety and operation

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
The following will be tested:

- Safety controls (e.g., water, air pressure switches)
- Combustion safety and efficiency
- Operational controls
- Fuel and water leaks
- Unit runs through complete cycle
- Local code requirements

Manufacturer specifications and all relevant industry standards will be met

Objective(s):
Ensure system functions safely with lowest possible cost of ownership

7.8103.2k - Maintenance records

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Occupants will be advised to keep records of all maintenance done to their system

Copies of or access to installation and operation manuals will be provided

Objective(s):
Improve chance of successful future maintenance or repair

7.8103.2l - Occupant health and safety

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):

All homes will have a carbon monoxide (CO) alarm

Objective(s):
Ensure occupant health and safety

7.8103.2m - Occupant education

Desired Outcome:
Safe, reliable, and efficient operation of the appliance maintained

Specification(s):
Completed work will be reviewed

Occupants will be educated on the safe and efficient operation and maintenance of the system, including:

- Adjustment of water temperature
- Target temperature in accordance with local code

Objective(s):
Ensure occupant is informed of the safe, efficient operation and maintenance of the system