Kansas SWS Field Guide - Supplemental Specifications for Manufactured Housing

Standard Work Specifications

Field Guide for

Manufactured Housing

created by

Kansas Housing Resources Corporation
# Health and Safety

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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

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.
2.0105.4e - Combustible gas detection

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
2.0201.2c

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

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

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

Objective(s):
Alert occupant to CO exposure

Best Practice
Carbon Monoxide alarms should be installed according to local codes

All manufactured homes, even all electric homes, will receive CO alarms.
2.0201.3e

**Desired Outcome:**
Accurate information about appliance safe operation is gathered

**Specification(s):**
CAZ depressurization testing will be administered on all natural draft equipment

**Objective(s):**
Measure combined effect of mechanical system fans on combustion zone

**Best Practice**
Exhaust fans on, Check interior doors, Air handler on?
2.0201.3e - Depressurization test

1. Place manometer reference hose to exterior of house

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

3. Place test hose by combustion appliance

4. Take baseline reading

5. Turn on interior exhaust fans, including any clothes dryers

6. Is the air handler on?

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

8. Manometer reading should be within allowable limit (See 2.0299.1a-i)

9. If reading is within allowable limit, all is well
2.0201.3g

**Desired Outcome:**
Accurate information about appliance safe operation is gathered

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

For CO levels exceeding 200 ppm as measured or 400 ppm air-free measurement, service will be provided to reduce CO to below these levels (unless CO measurement is within manufacturer specifications)

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

**Objective(s):**
Measure CO and report excessive levels

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

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

**Tools:**
1. Combustion analyzer with probe
2. Drill
2.0201.3g - Carbon monoxide (CO) test in appliance vent

- CO levels cannot exceed 200ppm, or 400ppm air-free CO
- Test undiluted flue gases in induced-draft furnaces
- Test undiluted flue gases in natural draft water heaters
- Test accessible exhaust outlets for power-vented appliances
- Test accessible exhaust outlets for direct-vent appliances
2.0201.3h

**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

Unsafe combustion appliances must be removed, repaired, or replaced before weatherization work

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

Testing at the conclusion of each day in which envelop or duct sealing measures have been performed is best practice. HVAC work must be completed before air sealing measures to minimize risk. Potential depressurization and drafting issues shall be identified and corrected before air sealing measures
2.0201.3h - Final test out

Complete spillage test using chemical smoke pencil

Complete carbon monoxide testing using a CO detector

Complete draft test using a manometer
**2.0202.1a**

**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

Refusal by client to remove an unvented heater will result in a deferral.
2.0202.1a - Removal

Secure permission to remove unvented space heaters from occupants

Ensure new combustion appliances are vented properly
2.0203.4b - 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 2012 IRC G2407 and authority having jurisdiction

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

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 tubes 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 tube within 12" of the ceiling, and one tube within 12" of the floor. The tubes may be concentric (one inside the other) to
save space, so long as the difference between the area of the larger and smaller tubes 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.
2.0203.4b - Additional combustion air (if action is required)

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.
**2.0203.4e**

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

**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 risks of high CO concentrations

**Objective(s):**
Ensure occupant can operate and maintain installations

Inform occupant regarding possible CO hazards

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*Before*

Occupants may be unfamiliar with CO alarms and proper operation and maintenance

*After*

Clear and effective communication with occupants can ensure the proper operation of CO alarms
2.0203.4e - Occupant education

All homes should have CO alarms installed, whether hardwired or battery-operated.

Discuss CO risks and proper operation of alarm with occupant.

Explain routine maintenance of alarm.
2.0204.1d

**Desired Outcome:**
Isolate combustion water heater closet from conditioned space

**Specification(s):**
Blower door assisted zonal pressure diagnostics will be used to verify isolation has been achieved

**Objective(s):**
Prevent combustion gases from entering living area

![Before](image1.png)  
**Before**  
The reading is closer to 0, indicating strong connection to the inside.

![After](image2.png)  
**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

Water heater CAZs zoned out of the conditioned volume of the home shall be isolated from the conditioned volume to the fullest extend feasible. Removal of the water heater to air seal is not recommended.
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.
2.0403.4a

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

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

**Objective(s):**
Reduce ground moisture entering crawl space

Manufactured housing with an enclosed, unvented area below the belly (typical of permanent foundations) will be treated like enclosed crawlspaces and will have a vapor barrier installed. Manufactured Housing with typical skirting will be considered an open crawlspace and no vapor barrier is warranted.
2.0602.2d

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

Specification(s):
If aluminum wiring is present and there is a concern about the safety of its condition or the proposed work scope has the potential to compromise the safety of the wiring, 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

A licensed electrician will only be required to inspect aluminum wiring in manufactured homes when there is a safety concern or when the proposed work scope has the potential to negatively impact the condition of the aluminum wiring.
3.1001.4d

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

**Specification(s):**
Ceiling repair material must meet or exceed strength of existing ceiling material

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

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

All accessible damaged vapor barriers will be repaired

Penetrations through the air barrier must be repaired

**Objective(s):**
Ensure ceiling is structurally sound

Minimize air leakage

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

Ensure sealant does not fall out

Before
Hole in drywall ceiling

In Progress
Drywall patch in place
### Tools:
1. 6-inch and 12-inch drywall taping knives
2. Sanding block or sanding sponge
3. Utility knife
4. Keyhole saw
5. Screw gun

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

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

Interior patch work should strive for the highest quality of finished product. Clients shall be informed and agree to the type of patching performed. Sheetrock and lath and plaster holes should be finished to provide a smooth, nearly paint ready surface. Minimal to zero sanding is the desire
3.1001.4d - Ceiling hole repair

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
3.1101.1c

**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
Like material and/or compatible materials should be used for repairs.
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.
3.1101.2c

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

**Specification(s):**
Like material and/or compatible materials will be used for repairs

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

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

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**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

---

**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
3.1101.3b

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

Specification(s):
All accessible holes and penetrations in top and bottom plates will be sealed

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

Objective(s):
Minimize air leakage

Maintain durability

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

Ensure sealant is effective and durable

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

Before
Cobwebs may indicate air leaks at the marriage line

After
Completed air sealing at marriage line
3.1101.3b - Marriage wall air sealing of holes and penetrations
3.1101.3b - Marriage wall air sealing of holes and penetrations

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

**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

**Tools:**
1. Reusable spray foam gun
2. Caulking gun
3. Utility knife
4. Screw gun
5. Blower door
6. Chemical smoke dispenser

**Materials:**
1. Caulk
2. Spray foam
3. Foam board
4. Screws

Identify leaks in marriage line using a blower door
3.1101.3c - Marriage line air sealing

Identify leaks in marriage line using a blower door and smoke

Foam, caulk, and seal leaks between halves of double wide manufactured homes
3.1201.6c

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

Specification(s):
Operable interior storm windows will be installed in accordance with manufacturer specifications

Objective(s):
Minimize air leakage

Provide safe egress for occupants

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

Interior Storm Windows must be audit approved
3.1201.6c - Installing operable storm window

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

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

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

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

Storm window has been installed according to manufacturers specifications and operates smoothly.
3.1201.6d

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

Specification(s):
Interior storm windows will be operable and egress rated in egress locations

Objective(s):
Provide safe egress for occupants

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

Storm windows installed in egress (bedroom) windows must be operable or removable, and conform to the following standard: Voluntary Standard Egress Window Systems for Utilization in Manufactured Housing, AAMA 1704-85
3.1202.3e

Desired Outcome:
Glass complete and intact

Specification(s):
Replacement glass will be sized to original width, height, and depth
Stops will be replaced or installed
Glass will be sealed in accordance with original installation design
Glass will be selected with comparable tint and coating (color and look)
Tempered or safety glass will be used as required by local code

Objective(s):
Install, seal, and secure new glass in place

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
3.1202.3e - New glass installation

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
3.1301.1d

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

Specification(s):
Combustion air supplies will be labeled for identification and will not be blocked or sealed

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

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

Objective(s):
Ensure combustion equipment is not compromised

Minimize air leakage around penetrations

Before
Unsealed penetration through bottom board

After
Properly sealed penetration through manufactured home bottom board
Tools:
1. Outward clinching (stitch) stapler
2. Utility knife
3. Cordless driver/drill
4. Reusable foam gun
5. Caulking gun
6. Nail gun

Materials:
1. Belly/bottom board fabric
2. Belly/bottom board repair tape
3. Staples
4. Screws
5. Foam board
6. 1X2 nailers
7. Spray foam sealant
8. High quality exterior caulk
3.1301.1d - Bottom board penetrations

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

Seal around penetrations with compatible materials like foam board, belly board, house wrap, or Flex Mend (tm)
3.1601.5b

Desired Outcome:
Ducts and plenums properly fastened to prevent leakage

Specification(s):
Ducts will be fastened with a minimum of three equally spaced screws

Objective(s):
Ensure durable joints

Tools:
1. Drill

Materials:
1. Fasteners
3.1601.5b - Metal to metal

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

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

Tools:
1. Band tensioner
2. Brush

Materials:
1. Tie bands
2. Mastic or other appropriate sealant

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

After
Flexible duct should be securely fastened to metal ducting to prevent future dislocation and minimize leakage
3.1601.5c - Flex to metal

1. Apply mastic to flange
2. Slide inner liner onto flange with sealant
3. Using band tensioner, securely attach liner in place with tie band

4. Slide insulation and outer casing over metal ducting
5. Extend insulation and casing until in contact with other insulation
6. Secure insulation and casing in place using tie band and band tensioner
3.1601.5e

Desired Outcome:
Ducts and plenums properly fastened to prevent leakage

Specification(s):
Metal take-off collar specifically designed for the thickness of the duct board will be used

All finger tabs will be bent down securely

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

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

Objective(s):
Ensure durable joints

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

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

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.
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

**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

**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

**Tools:**
1. Drill
2. Hammer

**Materials:**
1. Metal screws
2. Ring-shank nails

Before
Unattached ducts are useless

After
Damaged ducts should be repaired and securely fastened and sealed
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

**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

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

**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
contraction. Mastic and mesh tape also form a strong, permanent seal. Spray foam may be used to seal boots into the opening once the boot is fastened in place.
3.1601.5h - Boot to gypsum

1. Remove diffuser

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

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

4. Wipe away excess caulk (use water on siliconized acrylic, alcohol on silicone, and solvent on polyurethane caulk)
3.1601.5i

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

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
3.1602.8b

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

**Specification(s):**
Debris will be removed

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

Floor will be prepared to receive the appropriately sized plenum

**Objective(s):**
Provide unobstructed path for work access and air flow

Ensure adhesion of materials to be installed

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

---

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

**Materials:**
1. Rags

---

**After**
Closet prepared for furnace installation
3.1602.8b - Preparation

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

Vacuum cabinet clean.

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

Scrape loose material from insides of cabinet.

Apply mastic to inside seams of plenum.
3.1602.8c

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

**Specification(s):**
Plenum will be rebuilt or repaired using compatible materials and will be:

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

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

**Objective(s):**
Minimize restrictions

Maximize air flow and air distribution

Minimize moisture issues

Prevent condensation on plenum

---

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

**In Progress**
Rebuilding and sealing a leaky existing plenum
Materials:
1. Starting collars and flanges
2. Zip ties
3. Mastic duct sealant
4. Fiberglass mesh tape
5. Sheet metal screws
6. Turning vanes
7. Duct board

IF the plenum is significantly damaged or leaky, it should be repaired or rebuilt to these specifications.

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

Specification(s):
Point of access options include:

Option 1: Through the trunk duct
- Repair and seal access hole in the trunk duct
- Install insulation
- Repair belly/bottom liner

Option 2: Remove crossover duct
- Reattach crossover duct
- Seal and insulate crossover duct
- Repair belly/bottom liner

Option 3: Remove air handler
- Install new gasket, if necessary
- Mechanically attach furnace to the structure
- Reconnect utilities
- Replace and seal panels

Option 4: Through the furnace panel
- Replace and seal panels

Objective(s):
Repair work access
Prevent condensation
Minimize heat loss and heat gain from plenum
Various methods can be employed, but the key is to seal the furnace to trunk duct connection.

**Tools:**

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

**Materials:**

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

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

Always wear hand protection when working with sharp objects.
3.1602.8d - Repair work access

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

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

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

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

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

Plenum to duct trunk connection coated with mastic sealant.
3.1602.9a

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

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

- Location
- Types
- Leakage points

**Objective(s):**
Verify scope of work

In Progress

Locate the best access and egress points

Locate crossover duct and determine what type of system will work best for home
3.1602.9b

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

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

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

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

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

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

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

When feasible, 26-gauge hard duct should be installed

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

Objective(s):
Ensure lasting durable connections

Minimize air leakage and heat transfer

Maintain duct diameter around the turns

Maximize air flow and distribution
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
3.1602.9b - Flexible crossover duct connections

1. Attach elbow duct and orient in correct direction to minimize duct run.
2. Fasten elbow in place with at least three evenly-spaced fasteners.
3. Apply mastic at metal-to-metal connection.
4. Apply mastic to all elbow joints and flange.
5. Slide inner liner onto flange with sealant.
6. Fasten inner inner with tie band using band tensioner.
7. Extend insulation and exterior casing up over elbow until they reach belly.
8. Secure insulation and outer casing place with tie band.
9. Use band tensioner to ensure that insulation and casing remain tight against belly.
3.1602.9c

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

Specification(s):
Crossover ducts will be installed so they are not in contact with the ground

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

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

Objective(s):
Maximize air flow and distribution

Minimize condensation

Minimize air leakage and heat transfer

Before
Flexible ducting should not come in contact with ground

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

Tools:
1. Drill
2. Utility knife

Materials:
1. Fabric straps
2. Fasteners
3.1602.9h

**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. Blower door
2. Manometer
3. Pressure Pan

Using a pressure pan, measure and record the pre and post duct leakage. With the HVAC system off, use a blower door to depressurize the home to -50 pascals. Measure and record all pressures for duct boots where accessible. Sealed ducts should read near 0 pascals. Completely disconnected ducts will read closer to -50 pascals. Determine leakage area and feasibility to minimize duct leakage.
3.1602.9h - Performance testing

Set-up blower door to perform pressure pan testing. Depressurize to -50 pascals

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
3.1602.10b

**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

**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

---

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

---

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

*After*
The duct has been sealed, ensuring proper airflow to the home.
Measure the dimensions required for the new boot.

Fit the new boot on to the trunk line.

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

Mechanically fasten the boot to the subfloor.

Install a new grille on the rebuilt boot.
3.1602.10d

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

Specification(s):
Access hole in the trunk/branch duct will be repaired and sealed
Insulation will be reinstalled
Bottom liner/belly will be repaired

Objective(s):
Repair work access
Minimize heat transfer

Before
Access hole cut into manufactured home branch duct

After
Repaired, insulated, and sealed access hole in manufactured home duct and belly
**Tools:**
1. Utility knife
2. Disposable brushes
3. Outward clinching stapler
4. Scissors

**Materials:**
1. Fiberglass mesh tape
2. Mastic duct sealant
3. Foil tape
4. Insulation
5. Belly repair tape
6. Belly wrap
7. Staples
8. Solvent (acetone, paint thinner, denatured alcohol, Goof-Off, or similar) to clean aluminum duct
9. Spray adhesive for belly repairs
3.1602.10d - Repair work access

Thoroughly clean duct with solvent before applying foil tape and mastic

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

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

Replace or reinstall fiberglass belly insulation

Apply belly repair tape and fasten with outward clinching (stitch) staples. Spray adhesive will help adhere the tape
3.1602.11a

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

**Specification(s):**
Any closure system used will meet or exceed applicable standards

**Objective(s):**
Ensure effectiveness of air sealing system

Mastic sealant is an approved, durable, and effective sealant

**Tools:**
1. Utility knife
2. Disposable brushes

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

2. Continuously welded and locking-type longitudinal joints and seams in ducts operating at static pressures less than 2 inches of water column (500 Pa) pressure classification shall not require additional closure systems."
3.1602.11a - New component to new component sealant selection

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

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

Use tape to assemble joints, then coat with at least 2mm of mastic
3.1602.11b

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

**Specification(s):**
Duct surface to receive sealant will be cleaned

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

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

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

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

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

**Objective(s):**
Eliminate air leakage into or out of ducts and plenums

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

Reinforce seal

Support mastic and fiberglass mesh during curing

![Before](Unsealed metal ductwork)

![After](Mastic and mesh tape used to seal metal ductwork)
Tools:
1. Zip tie tensioning tool
2. Utility knife
3. Disposable brushes
4. Tin snips
5. Screw gun

Materials:
1. Mastic
2. Fiberglass mesh tape
3. Metal starting collar
4. Foil tape
5. Sheet metal
3.1602.11b - New component to existing component

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

**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

---

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

**After**
Sealed ductwork connections help prevent leakage

**Tools:**
1. Brush

**Materials:**
1. Mastic
2. Fiberglass mesh tape
3.1602.11c - Existing component to existing component

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
3.1701.1h

**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

---

**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

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Holes in the floor should be repaired

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

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3.1701.1h - Floor repair

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
4.1003.10b

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

**Specification(s):**
Special precautions will be taken to limit fiberglass and construction dust exposure to the occupant and occupant belongings

**Objective(s):**
Protect occupant health and safety

Protect occupant belongings

**Tools:**
1. Utility knife

**Materials:**
1. Plastic sheeting
2. Removable, low-residue tape
**4.1003.10c**

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

**Specification(s):**
Equidistant holes will be drilled in a straight row parallel to the longitudinal exterior wall of the ceiling

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

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

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

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

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

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

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

Determine insulation installation technique

Prevent damage to ceiling

Create a professionally finished ceiling
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

Plastic plugs will be allowed for manufactured homes with written client permission.
4.1003.10e

**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.

Clarification: fill tube will be able to reach within 6 inches of the end of each cavity when inserted. Blown fiberglass will be used as the allowed insulation for manufactured housing.
4.1003.10e - Fiberglass blown insulation installation

If insulation is roof mounted, blow below it.

If insulation is ceiling mounted, blow above it.

If insulation is mounted at both the ceiling and the roof, blow between it.
4.1003.10f

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

**Specification(s):**
Holes will be plugged or covered and sealed to be aesthetically pleasing

If existing trim was removed, it will be reinstalled

**Objective(s):**
Create an airtight seal

Create a visually acceptable ceiling finish

![In Progress]

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

**Tools:**
1. color matched plug

**Materials:**
1. color matched plug

Plastic plugs will be allowed for manufactured homes with written client permission.
4.1003.10g

**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.
4.1303.1a

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

**Specification(s):**
Insulation will be installed in accordance with recommended R-value and density

**Objective(s):**
Insulate to prescribed R-value for the climate zone

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

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

Install insulation per audited approved work order instructions. Outriggers should be filled full with appropriate density to avoid settling. Bellies should be filled full with appropriate density to avoid excessive weight. Bellies are typically not dense packed and minimal settling is acceptable.
4.1303.1e

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

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

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

**Objective(s):**
Document job completion to contract specifications

Confirm amount of insulation installed

Ensure ability to match bags required for total area completed

Comply with 16 CFR 460.17

**Best Practice**
Provide occupant with signed, dated receipt documenting information about insulation installed
4.1303.1e - Occupant education

- Documentation should include insulation material and r-value
- Provide occupant with copies of all documentation
- Communicate professionally with occupant to provide information and support
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

Blown fiberglass is the preferred insulation material for manufactured homes. Cellulose will not be installed. Belly repair and blow in fiberglass is option #1. Use the steps shown here as option #2 if the floor is completely accessible and open and it makes sense to use batt insulation.
4.1303.2c - Insulate floors

1. If fiberglass insulation is kraft-faced, ensure kraft is in contact with subfloor.
2. Notch insulation around pipes, blocks, and other obstructions.
3. To prevent insulation from moving away from subfloor, supports should be fastened in place.

4. A rigid air barrier should be securely in place so prevent sagging, gaps and penetrations should be sealed.
5. When ductwork or water pipes run below joists, insulation should be threaded above to fill joist cavity, uncompressed.
6. Water lines and ducts should be insulated if running below joists.

7. A rigid air barrier should be mechanically fastened to hold it tight against the floor joists.
8. When insulating around low-hanging ducts and water pipes, run a line of sealant before placing insulation.
9. Insulation around ducting should be securely fastened and sealed to maintain air barrier.
4.1303.2d

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

**Specification(s):**
Insulation materials will be of minimal water absorbency and flame spread, and smoke-developed index for insulation will be in accordance with 2012 IRC 2012, Sections R302.10.1 through R302.10.5

Foam plastic insulation will comply with 2012 IRC 2012, Section R316

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

Use blown fiberglass only in manufactured homes.
4.1303.2d - Materials

XPS insulation board is a non-absorbent insulation option.

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

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

Use only corrosion resistant, exterior screws as fasteners in floor cavities.
4.1488.1b

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

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

If heat tape is needed, it will be installed this way. There is no requirement to install heat tape on existing waterlines and condensate lines.

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

Educate occupants on efficient and safe operation and maintenance of heat tape.
4.1488.1b - Installation

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

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

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

4. Fasten insulation to water lines with zip ties.

5. Cover all exposed portions of the water supply lines with insulation.
**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

**Tools:**
1. inspection mirror

**Materials:**
1. mastic
2. duct boot

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

*After*
The duct boot has been properly sealed, even though the area is difficult to reach.
4.1601.4i

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

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

**Objective(s):**
Minimize thermal conductance of the duct system
Minimize condensation

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Before
This elbow has been sealed, but is not insulated.

After
Fitting has been sealed and properly insulated.
**4.1601.4j**

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

**Specification(s):**
Vapor barrier of all duct insulation will be taped to the flex duct using the taping system required by the manufacturer of the duct insulation

Vapor barrier will be sealed to the belly liner

**Objective(s):**
Ensure a complete vapor barrier

![Crossover duct with vapor barrier mended and sealed to manufactured home belly](image)

**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.
5.3003.5a

**Desired Outcome:**
Refrigerant lines properly installed

**Specification(s):**
All liquid refrigerant lines will be insulated to a minimum of R-4

Vapor or high side lines will not be insulated unless specified by the equipment's manufacturer

Suction lines will be insulated to a minimum of R-4

For mixed humid, hot humid, and marine climates, heating and cooling refrigerant lines will be insulated

**Objective(s):**
Ensure refrigerant lines do not gain excessive heat

Prevent energy loss and condensation

**Best Practice**
Refrigerant line set should be insulated to an R-4 to maintain performance
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, 2012 IRC N1103.3.1, 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.

Use rubberized pipe insulation for exterior conditions. Regular foam insulation not to be used.
5.3003.14e

**Desired Outcome:**
Analysis of critical components and operations completed in accordance with industry and manufacturer specifications

**Specification(s):**
CO in the undiluted flue gas will be less than 200 ppm as measured or 400 ppm air-free measurement (unless CO measurement is within manufacturer specifications)

**Objective(s):**
Ensure equipment:
- Operates as designed
- Operates safely
- Operates efficiently
- Is durable

**Best Practice**
CO levels should be less than 200 ppm to ensure safe operation
**5.3003.14f**

**Desired Outcome:**
Analysis of critical components and operations completed in accordance with industry and manufacturer specifications

**Specification(s):**
All testing and inspection holes will be sealed with manufacturer approved materials

**Objective(s):**
Ensure equipment:

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

**Materials:**
1. high temperature sealant
2. stainless steel plug or cap
3. stainless 5/16” bolt

Foil tape will be allowed on single wall pipe.
5.3003.14f - Testing/inspection holes

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.
6.6003.5c

**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

![Manometer](image1.png)

In Progress
Pressure should be measured in the CAZ to verify combustion appliances operate safely.

![Best Practice](image2.png)

Best Practice
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
6.6003.5c - Combustion safety

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.
6.6205.1c

**Desired Outcome:**
Provide primary ventilation for common spaces

**Specification(s):**
No resistance greater than 3 pascals will exist between fan intake location with reference to the common area

Exhaust ventilation for common spaces will not be installed in bedrooms

**Objective(s):**
Ensure fresh air distribution to common areas

**Tools:**
1. digital manometer

The installation of whole house continuous exhaust ventilation in bathrooms will be allowed where it makes sense to do so and where excessive pressure differences don’t result. Client’s will be educated on the need to keep bathroom doors open when not in use where continuous ventilation has been installed.
6.6205.1c - Location

Locate the fan in question. Connect a hose, and turn the manometer on to PR/PR. Turn on the exhaust fan.

If the pressure difference is greater than 3.0 pascals, pressure relief is needed.

If pressure relief is needed, it can be provided by a through the door transfer grille.

After pressure relief has been provided recheck the numbers, ensuring a reading within range.
6.6205.1f

**Desired Outcome:**
Provide primary ventilation for common spaces

**Specification(s):**
Occupant will be educated on:

- Purpose of the ventilation system
- Proper operation and use of controls
- Cost and benefit of system
- Manual shut off

A label indicating the presence and purpose of the ventilation system will be included or a copy of the system operation guide will be posted at the electrical panel

Operation guide or label will be permanently attached and in full sight

**Objective(s):**
Ensure occupant is educated on the safe and efficient operation of the system

Deliver intended air exchange

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**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.
7.8102.2e

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

**Specification(s):**
A potable water expansion tank will be installed on the cold water side of newly installed water heaters when required by local code.

A direct connection with no valves between the storage tank and expansion tank will be installed in accordance with the 2012 IRC, authority having jurisdiction, and according to manufacturer specifications

**Objective(s):**
Protect the storage tank from expansion

![Bad Practice](image1.png)
Need to eliminate the valves between the storage tank and expansion tank

![Best Practice](image2.png)
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 weatherization installed replacement water heaters where required by code.
7.8102.2i

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

**Specification(s):**
If additional tank insulation is installed, it will be rated a minimum of R-11 and will be installed to manufacturer specifications

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

Pipe insulation must remain 3” from gas water heater vent

Heat traps will be installed on the inlet and outlet piping where not provided by manufacturer

**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
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.
**7.8102.2i - Thermal efficiency**

1. Clean the entire outside of the water heater.
2. Wrap blanket around tank and mark it where it overlaps. Add two or three inches and cut off using a straightedge and raz.
3. Cut the insulation off at the mark. Peel away the excess insulation, leaving a flap of vapor barrier.
4. Pull insulation blanket around the tank.
5. Staple the flap to the blanket with outward clinching staples or use long zip ties to secure the blanket in place.
6. Cut out around drain valve, P&T relief valve, and thermostats. Do not cover combustion access or air supply on gas units.
7. Use remaining insulation for the top of electric water heaters. Tape up seams in the vapor barrier. Insulate water lines.
7.8102.3d

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

Specification(s):
An emergency drain pan will be installed with sides that extend a minimum of 4" above floor if leakage would cause damage to the home and in accordance with P2801.5 of the 2012 IRC

A ¾" drain line or larger will be connected to tapping on pan and terminated in accordance with P2801.5.2 of the 2012 IRC

Objective(s):
Collect and safely dispose of water escaping from the storage tank

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

Pans are necessary on new installs IF leakage would cause damage to the home. Pans are necessary and shall be installed on all new water heaters in manufactured homes.
7.8102.3h

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

**Specification(s):**
Any accessible hot water lines at the appliance will be insulated to meet 2012 IRC N1103.4.2 or local requirements, whichever is greater

**Objective(s):**
Reduce line losses

![Image of insulated pipes]

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. Typical Foam pipe insulation R-values:

- 3/8" equals R-2 (NOT ALLOWED).
- 1/2" equals R-3.
- 5/8" equals R-4.

Maintain proper clearances from the water heater vent when installing foam pipe insulation.