# Duct Diagnostics and Repair

# Weatherization Installer/Technician Mobile Homes

Key Terminology

Aluminum brake

Aluminum coil stock

Belly return

Boot

Branch duct

Butyl-backed tape

Downflow furnace

Duct boot

Furnace plenum

Hallway return

Mastic

Pressure balancing

Pressure pan testing

Return plenum

Riser

Upflow furnace

Vent Free Area (VFA)

Section Transition

Learning Objectives (Slide #2)

By attending this session, participants will become aware of:

* How a mobile home’s forced air distribution system works.
* Mobile home duct configurations.
* Duct leakage problems and how to diagnose them.
* Materials and techniques to fix leaky ducts.
* How to modify a belly return system.
* Other duct system improvements.

*Ask participants about the kinds of experience they’ve had diagnosing and repairing ducts on mobile homes.*

Forced Air System Operation #1 (Slide #3)

* With the blower located at the top of the furnace cabinet, air is forced downwards across the heat exchanger and into the ducts located in the belly cavity.
* This type of furnace is known as a ***downflow furnace.***

*Q. How may this type of system differ from one located in the basement of a site-built home?*

*A. A furnace located in the basement of a site-built home has a blower that is located below the heat exchanger where air is forced upwards into the ducts attached to the based ceiling joists. This type of system is known as an* ***“upflow” furnace****.*

Forced Air System Operation #2 (Slide #4)

Mobile home forced air distribution systems can be classified as having either a central ***hallway return*** or ***belly return***.

Hallway Return System:

* Supply ducts run the length of the home and deliver air to various rooms. Return air is drawn back to the furnace through a louvered door at the furnace closet.

Belly Return System:

* The belly return system uses the belly cavity as a ***return plenum***. Air is drawn back to the furnace through a louver in the floor of the furnace closet.
* The belly return system is vulnerable when large holes or tears occur in the rodent barrier. This may cause unconditioned outside air to be drawn into the return system, which is likely to cause infiltration and moisture problems and lead to pressure imbalances in the home.
* A conversion to a hallway return system is therefore recommended.

Duct Components (Slide #5)

Photo showing a factory-assembled continuous straight duct run.

* The ***branch duct*** with the cylindrical ***boot*** will eventually be attached to the bottom of the furnace.

Duct Location (Slide #6)

* In a lengthwise floor joist configuration, the main duct is located inside the joist cavities.
* In a crosswise floor joist configuration, the main duct is located beneath the floor joists and connected by boots to the sub-floor.
* Mobile home duct systems are extremely vulnerable because they are located underneath the floor, which is the primary air barrier. As designed, ducts are separated from the outside by both the factory insulation and the rodent barrier. When ducts leak, they typically leak to the outside because the rodent barrier is often torn. All that separates the ducts from the outside is a thin rodent barrier, which is prone to damage over time.

Problems and Opportunities (Slide #7)

Photos of factory-installed duct systems sealed with duct tape.

* Duct design and components in factory-installed systems are inherently bad, even when they’re new. This is an opportunity for a retrofit.

Visual Checks #1 (Slide #8)

Photos of leaks at register locations.

Visual Checks #2 (Slide #9)

Photos of massive duct leaks under the floor.

Visual Checks #3 (Slide #10)

Photos of leaks at a branch duct and at the bottom of a duct.

Visual Checks #4 (Slide #11)

Photo showing that nearly two-thirds of the ***furnace plenum*** is blocked by a poorly fitted boot transition.

Visual Checks #5 (Slide #12)

Photo: Inside of a duct.

Insert a flashlight through the duct opening and lay it flat in the duct run. A mirror will reveal many problems, including holes, obstructions, and collapsed sections.

Visual Checks #6 (Slide #13)

* Concentrate on the following locations: ***riser***, ends, branch ducts, and the furnace plenum.
* You may need to cut the rodent barrier to access some leaks.
* Use a flashlight and mirror.
* Use ***pressure pan testing***.
	+ A pressure pan is a tool that uses a differential pressure manometer and a hood to create a tight seal between the duct register and the floor, and measure the pressure in the ducts with reference to the home.

Pressure Pan Testing (Slide #14)

* Depressurize the home to 50 Pa.
* Pressure pan each register location.
* Record pressure differences.
* Repair ducts and retest.
* The goal is to reduce pressure pan readings at each register location to less than 1 Pa.
	+ With the blower door depressurizing the house to 50 Pa, the auditor should read a number between 0 and 50 Pa after placing the hood over a duct register.
	+ A high number indicates that there is a major connection to the outside.
	+ Numbers closer to 0 Pa indicate less of a connection to the outside.

*Show and tell: Pressure pan and digital manometer.
Offer a case study about sequential pressure pan-guided testing.*

Repairing and Sealing Ducts #1 (Slide #15)

* Duct repair and sealing techniques.
* Inspect ducts and boots.
* Repair or replace ducts and boots.
* Clean ducts.
* Seal with ***mastic*** and fiberglass mesh tape.
* Seal ends of trunk line.
* Repair and seal furnace base.

*Show and tell: Duct sealing materials.*

Repairing and Sealing Ducts #2 (Slide #16)

* Inspect for blockage and loose seams.
* Check the flanges and inspect for damage.

Repairing and Sealing Ducts #3 (Slide #17)

* Repair procedures should always begin with a thorough cleaning. Wipe down the areas to be sealed with alcohol-soaked rags. Adhesion of sealing materials such as mastic, butyl tapes, and caulk depends on having clean metal surfaces.

Repairing and Sealing Ducts #4 (Slide #18)

Photo of boot repair.

* A ***duct boot*** or riser is a transition piece that connects the main duct to the floor. It is vulnerable to failure.

Repairing and Sealing Ducts - Materials #1 (Slide #19)

* For severely damaged duct boots and risers, fabricating boots from scratch using ***aluminum coil stock*** may be the only choice.
* A tool known as an ***aluminum brake*** is used to produce crisp 90-degree bends.
* Components are screwed together and fastened to the main duct and floor.

*Show and tell: Specialized duct fabricating tools and finished duct components.*

Repairing and Sealing Ducts – Materials #2 (Slide #20)

***Butyl-backed tape***

* Aluma-Grip tape is a heavy-duty, pressure-sensitive duct joint rolled sealant. It provides an aggressive water-resistant grip to most surfaces, including sheet metal, duct board, flex duct, PVC coated duct, and duct wrap vapor barriers.

*Show and tell: Butyl-backed tape.*

Repairing and Sealing Ducts – Materials #3 (Slide #21)

Mastic sealant

* Mastics permanently seal the joints and seams of all air duct types.
* RCD #6 mastic seals leaks in return air ducts, supply ducts, air handlers, plenums, grilles, registers, dampers, and boots.
* Application is easy with a brush, a trowel, or your palm.

*Show and tell: Mastic applied to a section of duct.*

Sealing with Mastic #1 (Slide #22)

* Use fiberglass mesh tape to span gaps larger than ¼ inch.
* Latex gloves are often your mastic brush.

Sealing with Mastic #2 (Slide #23)

* Seal the end of the trunk line by stuffing backer material such as coarse furnace filter scraps into the duct past the last register and seal with mastic.
* Use screws to hold carpet up until mastic dries.

Repairing and Sealing Ducts #1 (Slide #24)

Photo on left: A large leak midway down the main duct required access through the rodent barrier.

* Seal the duct with aluminum coil stock and mastic. Then patch the belly board.

Photo on right: The end of a duct was repaired with screws and butyl-backed tape.

Repairing and Sealing Ducts #2 (Slide #25)

Photo of reinforced ductwork.

* Since mobile homes are often moved, ducts may have sagged or become disconnected. Reattach to the bottom of the floor joists with aluminum straps.

Repairing and Sealing Ducts - Review (Slide #26)

* Concentrate on the following locations:
	+ Risers.
	+ Ends.
	+ Branch ducts.
	+ Furnace plenum.
* You may need to cut the rodent barrier to access some leaks.
* Never use duct tape.
* Mechanically fasten components where necessary.

Post Pressure Pan Testing (Slide #27)

Photos of post pressure pan test results:

* You only have one shot to get it right.
* Once the belly has been insulated, there’s no going back.
* The goal is to seal the duct system so that pressure pan readings are 1 or less.

Belly Return System Conversion #1 (Slide #28)

* Permanently seal all return registers (including the register in the floor of the furnace closet).
* Create a hallway return system.
* Add a louver to the furnace closet door.
* Undercut doors to adjacent rooms or provide louvers.
* Verify good airflow with a ***pressure balancing*** test:
	+ The belly return system uses the belly cavity as a return plenum where air is drawn back to the furnace through a louver in the floor of the furnace closet.
	+ The belly return system is vulnerable to being compromised when large holes or tears occur in the rodent barrier. This will cause unconditioned outside air to be drawn into the return system, which is likely to result in infiltration or moisture problems and lead to pressure imbalances in the home.
	+ Conversion to a hallway return system is therefore recommended.
	+ The illustration shows the elimination of all floor returns that communicate with the belly cavity.

Belly Return System Conversion #2 (Slide #29)

Photos of sealed belly return registers in the furnace closet.

* Seal belly return registers in the furnace closet.

Belly Return System Conversion #3 (Slide #30)

Photo on left: Return may extend behind the furnace cabinet and must be sealed.

Photo on right: Aluminum coil stock was fastened to the floor with hex-head screws.

Belly Return System Conversion #4 (Slide #31)

Photos: Use a variety of materials, including plywood and duct board to permanently seal registers.

* Permanently seal all return registers.

Belly Return System Conversion #5 (Slide #32)

Photo: A louver in the furnace closet door completes the process of creating a hallway return system.

* Install a return louver in the furnace closet door. Installing a commercially available louvered door would actually be a better option because it’s less labor intensive than cutting and fitting grills into the existing door and will look better.
* Leave 2 square inches of ***Vent Free Area (VFA)*** per 1,000 BTU of furnace input.

*Q. How much VFA is required for a furnace closet return louver for a furnace with a 50,000 BTU input?*

*A. 2 x 50 = 100 square inches*

Pressure Balancing the System (Slide #33)

Measure room pressure imbalances.

* Room pressure imbalances over 4 Pa should be remedied by adding supply or return air, then retesting.
* Make sure that doors to interior rooms are sufficiently undercut to allow air to return to the furnace. Installing a return air grill into the door is also acceptable.
	+ Closed doors that prevent supply air from getting back to a return may cause positive pressures in those rooms.
	+ Meanwhile, the return side of the system is starved for air, causing negative pressure in the zone where the return is located.
	+ Use a manometer for testing the pressure difference across a bedroom door with the forced air system running.
	+ Place the hose on the input tap of the manometer to measure the pressure of the room with reference to the house.
	+ Closed doors to rooms with no returns increase the air pressure in the room, causing duct-induced air leakage and comfort problems.

*Show and tell: Digital monometer with hose attached. Simulate a pressure balance test through the door of the classroom if possible.*

Other Duct System Improvements (Slide #34)

* Replace damaged registers.
* Remove obstructions.
* Balance the system:
	+ Install baffles to enhance airflow to distant rooms.
	+ Shorten the end of duct runs beyond the last register.
	+ Enhance airflow by removing obstructions, replacing damaged registers, and shortening unneeded duct runs.

*Show and tell: A damaged and replacement register.*

Summary (Slide #35)

* Mobile home ducts are very prone to leakage.
* Diagnosing and repairing duct leakage is the single most cost-effective measure you can apply to mobile homes.
* Effective duct sealing is possible through the use of innovative duct sealing materials.
* Other duct improvement measures such as cleaning, removing obstructions, and system balancing can improve comfort and lower fuel bills.