

Appendix I: Evaluating Ductwork

How to Evaluate Furnace Duct Work & Cure Short Cycling or Inadequate Ductwork Problems

Overview:

The amount of supply and return ductwork a hot air furnace has, can have a large effect on the actual efficiency of the unit, as well as the life expectancy of the unit. If there isn't enough duct work to deliver the heat the furnace produces, obviously clients are cold, operating costs go up, efficiency goes down, and eventually a premature crack in the heat exchanger will result (the furnace can't get rid of the heat and it stresses out the metal in the heat exchanger)

This bulletin is meant to help guide the energy auditor through the steps of evaluating furnace ductwork and its' efficiency. And when necessary, helping to cure the inadequate ductwork (short cycling) problem. Evaluating ductwork with a heat rise test should be done at every audit, and any problem cured. It doesn't take a lot of time, but huge improvements will result. This is what Weatherization is about.

Definition of Short Cycling (also called Shutting Off or Rocking on the High Limit):

Short Cycling is when the burner shuts off before a call for heat is met (t-stat setting isn't reached). It is shut off by the fan limit switch as a safety measure. The air handler will keep running. The temperature in the plenum will go down and the burner will come on again, only to shut off again quickly. This rocking back and forth on the hi limit setting is bad for the furnace. The heat exchanger is seeing temperatures it wasn't designed for, and will crack. It is also very inefficient and doesn't allow proper heat to be distributed to the living space.

Steps to enable auditor to evaluate furnace duct work:

1. Before performing your furnace combustion test, remove the cover off of the fan limit switch so that it is visible. Record the fan on, fan off, and hi limit settings. Keep an eye on this and note if the burner shuts off on the high limit switch when operating. It shouldn't. Adjusting these settings won't cure a short cycling problem. But it can affect the comfort of the client. Suggested Settings:
 - ✓ Fan ON: 130 degrees or lower
 - ✓ Fan OFF: 110 degrees or lower
 - ✓ High Limit: no higher than 200 degrees unless specified by manufacturer
2. **Heat Rise test:** Drill a small hole in a supply duct a few inches from where it exits the supply plenum (instead of in the plenum, so the thermometer doesn't see the heat exchanger) and then in the center of the return plenum. Place a digital or dial thermometer in both holes.



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Steps to enable auditor to evaluate furnace duct work (continued):

3. Perform your efficiency test, and before shutting off the furnace record the Temperatures in the supply and return side. Subtract these numbers and the difference will be the **heat rise** of the furnace. For a furnace with adequate duct work this heat rise should fall in the range of **45 degrees to 70 degrees**. Or check the exact specifications of the manufacturer (listed on the unit).
4. If the heat rise is outside that range and or the furnace is shutting off on the high limit switch, **see below**. If the heat rise is good, you are done evaluating.

What to do if Heat Rise is Excessive, or if furnace Short Cycles:

1. First check to ensure that the air filter is clean, and that all the registers in the living space are open and not obstructed with furniture or clothing, or covered with filter or cheese cloth. If they are, uncover or open them all and try again.
2. To determine if supply or return is inadequate, measure the amount of duct work that is coming off of the plenums, and check the charts below.
 - ✓ NOTE: Always check the size of the nozzle. It should be listed on an efficiency report, or on the unit itself. Downsizing the nozzle will occasionally cure short cycling (but don't downsize below manufacturers specs., and make sure the new nozzle provides enough heat for the home).
 - ✓ NOTE: a dirty or broken air handler, or slipping belt can cause an excessive heat rise and short cycling. Increasing blower speed can cure this, but will increase noise and discomfort at end of cycle. It is best to install adequate duct work first.

TIP: To quickly determine if the return ductwork is limiting, remove the return cabinet door and allow the furnace to run. If it doesn't short cycle, this open door has provided enough return air and you know you must install more return duct work.



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Determining the Amount of Ductwork needed:

1. If a gas furnace, take the gas input and go to Table 1 to see what the approximate amount of square inches of supply and return duct is needed coming off of the plenums. (Use Table 3 to get the equivalent square inches for the appropriate round ducts. For rectangular ducts take the length times the width in inches to get square inches)
2. If an oil furnace, take the nozzle size times 138,200 Btu/ gallon times the efficiency to get the output, and go to Table 2 to determine the square inches of Supply and Return needed. (Or use CFM air flow if you are more familiar with that).
3. Determine which you are lacking in, supply or return and install a duct to the living space off of the plenum.

Tips and Traps:

1. Be wary of installing 6" ductwork. It moves very little air relative to 7 or 8". An 8" duct moves twice as much air as a 6" duct.
2. Remember, air flow is limited by the smallest restriction. For example, if you have a 10" duct (79 square inches) that supplies air to a 28 square inch register, you are only moving the amount of air that a 6" duct (28 square inch) would move. You need a larger register, at least 79 square inches, to supply all the air the 10" duct can move.
3. An 8 inch duct that Y's to 2 8 inch ducts only moves the amount of air of one 8 inch duct. Not a good design.
4. When installing new ductwork to improve air flow, always come off the plenum, not off of existing trunks or ducts (unless there is enough air flow available from the trunk).
5. Don't come off of the plenum with elbows or 90's. Use gradual boots if possible. Elbows cut the air flow dramatically.
6. Smooth walled duct work is recommended over flex duct. Although cheaper, flex duct kinks easy, has more resistance to air flow and isn't as durable.



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Table 1: Chart of Square Inches of Ducts Needed (off both the supply and return plenums) for gas furnaces.

Gas furnaces	
Input BTU's	Square inched of Ducts needed (supply and return)
40,000	80 si each, supply and return
60,000	120
80,000	160
100,000	200
120,000	240

Table 2: Chart of Square Inches of Ducts and CFM air flow needed for various oil furnace sizes.

Oil furnaces		
Output BTU's	Square Inches Duct needed (S & R)	Min. CFM Airflow
45,000 to 55,000	100 each s, and r	500
60,000 to 70,000	140	700
75,000 to 85,000	170	800
95,000 to 106,000	190	900
106,000 to 115,000	220	1100
125,000 to 150,000	280	1400

Table 3: Chart of Round Duct to Square Inch to CFM Air Flow to Heating BTU's.

Diameter	Square Inches	CFM Air Flow	Heating BTU's
6"	28	100	7,400
7"	38	145	10,700
8"	50	210	15,600
9"	64	290	21,500
10"	79	390	28,900
12"	113	620	45,900



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Examples of improper duct work:



An 8" supply branches to 2 8" supplies. It is only moving one 8" duct worth of air, not 2 like this contractor hoped. Cure: Each register should have been supplied with it's own duct coming from the plenum.



This return duct is moving only 8" worth of air (it's smallest restriction) not a full 12" as the contractor has hoped with his new 12" duct on right of this picture. This should have been 12" duct all the way to the floor register which would have needed to be enlarged to 113 square inches.

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Examples of improper duct work:



A dirty air filter will cut down air flow. Always leave a furnace with a clean air filter and attempt to educate the importance of such, to the client. Emphasize they will feel more heat from their registers when their furnace has a clean filter.

This bulletin was written as a guidance to evaluate and cure inadequate duct work problems, which are commonly found on Vermont Weatherization Jobs. These charts and numbers are only guidelines. **If the furnace doesn't short cycle, and the heat rise is fine, and providing enough heat, don't add more duct work just because the chart says to! This is meant as a tool to help diagnose the cure. Use common sense!** If you have more specific questions about this, please give me a call at 769-8376. If I can't answer the question, I will find someone who can.

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Reference Material for this came from:

1. Saturn Mechanical Systems Field Guide
2. Bacharach (Rudy Leatherman)

