Will This Duct System Work?

Duct Sizing for Furnace & A/C Replacements

Conservation Services Group

Introduction

- How Much Air Do You Need?
- Comparing Old Furnaces vs. New Furnaces
- How Much Air Can You Move?
- Static Pressure, Friction Rate, and the Ductulator
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How Much Air Do You Need?

Old Furnace : 100,000 btu/hr input @ 80% AFUE
(80,000 btu/hr net output)

New Furnace: 80,000 btu/hr input @ 95% AFUE
(76,000 btu/hr net output)

Btu/hr (net output) = 1.08 x Air Flow x Temperature Rise

CFM = Net Btu/hr / (1.08 x ΔT)

How Much Air Do You Need?

Old Furnace Temperature Rise (ΔT) 50° - 80°F typical.
(Use 70°F)

$$\text{Original Air Flow} = \frac{80{,}000 \text{ but/hr net output}}{1.08 \times 70°\text{F } \Delta T}$$

$$= 1{,}058 \text{ CFM}$$

How Much Air Do You Need?

New Furnace Temperature Rise (ΔT) 40° - 65°F typical
(Use 55°F)

$$\text{New Air Flow} = \frac{76{,}000 \text{ btu-hr net output}}{1.08 \times 55°\text{F } \Delta T}$$

$$= 1{,}280 \text{ CFM !!!}$$

*Remember, Old furnace 1,058 CFM

How Much Air Can You Move?

- Every blower is rated to move air at a specified static pressure
- Static Pressure is a measure of the resistance/friction in the ducts
- Old furnaces used PSC motors with typical static pressure limits of 0.50 IWC maximum
- Newer furnaces, especially 95% models, use ECM blowers that will work against higher static pressure limits of 0.70 IWC or more
- If the ducts are undersized the ECM will compensate and Fix It

Right? **Yes and No**

How Much Air Can You Move?

- The Total Static Pressure rating of the blower is only one part of analyzing new or existing duct “systems”

- The Duct Calculator (or Ductulator) is often used to size ducts
  The proper use is based on the calculated Friction Rate / 100 ft.
  The F/R is based on greatest Total Equivalent Feet (TEF) of duct

- This may not be the longest section of duct, just the most restricted

- This is a basic version of the ACCA Manual D duct design process

How Much Air Can You Move

Based on the EXTENDED PLENUM FITTINGS example in the top right corner of the Ductulator, let's calculate a TEF and F/R

The duct system for a 32' x 24' cape with a chimney on the 24' wall

Supply Ducts	
Starting Collar	35 TEF
Trunk	15 ft
Reducer	5 TEF
Trunk	10 ft
Top takeoff	50 TEF
6 inch run	15 ft
End Boot	50 TEF

Return Ducts	
Return elbow	65 TEF
Starting collar	35 TEF
Trunk	15 ft

Total Equivalent Feet of Duct =
295 TEF

How Much Air Can You Move?

Friction Rate/100 ft of duct = Available Static Pressure (ASP) x 100
Total Equivalent Feet

ASP = Blower External Static Pressure – Device Pressure Losses

- Device Pressure Losses include supply register, return grille, balancing dampers, A/C coils, upgraded filters, etc.
- Anything not part of the OEM furnace assembly reduces the available blower static pressure and affects the air flow
- For an older furnace with a PSC blower motor, air flow drops at higher ESP
- A new ECM furnace with will maintain constant air flow, but it will use more electricity (***perhaps 2 or 3 times more***) to do so

How Big Do the Ducts Need to Be?

Old Furnace

Blower Static Pressure = 0.50 IWC

Device Pressure losses

Return Grille	0.03
Supply Register	0.03
Balancing damper	0.03

Available Static Pressure = 0.41 IWC

$$\text{Friction Rate/ 100 ft of duct} = \frac{0.41 \times 100 \text{ ft}}{295 \text{ TEF}}$$

$$= \mathbf{0.14\text{” per 100 ft}}$$

How Big Do the Ducts Need to Be?

Old Furnace

Set the Ductulator at the F/R of 0.14” and desired air flow of 1058 CFM

What size trunk duct is needed? 8” x 20” is pretty close

If the trunk is only 8” x 16”? At 0.14, only 800 CFM!

Is that bad?

What furnace problems can low air flow cause?

How Big Do the Ducts Need to Be?

New Furnace

But the New Furnace Needs 1280 CFM.

Why?

Lower temperature rise by design requires more air flow!

How Big Do The Ducts Need to Be Now?

At 0.14” Friction Rate 8” x 24” or 10” x 18” trunk is needed

How Big Do the Ducts Need to Be?

But the New ECM Furnace has Blower SP of **0.70 IWC**

Friction Rate = (ASP x 100) / TEF
= (0.61 x100) / 295
= 0.21 which allows 8” x 20” Trunk

The ECM Blower FIXED the Duct System!

Except, what’s that noise?
And why are the paintings being blown off the wall?
I think we have velocity issues….

What About Adding Air Conditioning?

That Changes everything!

Blower Static Pressure	=	0.70 IWC
Minus Device Pressure Losses		
AC Coil		0.25
Upgraded 1” filter		0.15
Register, Grille, Damper		0.09
Available Static Pressure	=	0.21 IWC

What About Adding Air Conditioning?

$$\text{Friction Rate} = \frac{0.21 \text{ IWC} \times 100 \text{ ft}}{295 \text{ TEF}}$$

$$= 0.07”$$

Set the Ductulator to 1280 CFM at 0.07” to find proper Duct Size

8” x 32” or 10” x 25” trunk is needed

Have you seen any 8” x 32” or 10” x 25” ducts in Capes lately?

HELP! How Can I Fix It?

You need 1280 CFM to protect the heat exchanger AND provide 3 tons of cooling!

Remember the Friction Rate Formula?

$$\text{Friction Rate} = \frac{\textbf{\textit{Available Static Pressure}} \times 100}{\textbf{\textit{Total Equivalent Feet}}\ \text{Duct}}$$

Two Options

1 - Increase ***Available Static Pressure*** with less restrictive air filters

2 - Make some duct repairs to ***reduce the TEF*** of duct

HELP! How Can I Fix It?

If we re-work the ducts and use a less restrictive media filter, look what happens

Improved Supply Ducts	
Starting Collar	10 TEF
Trunk 15 ft	15 TEF
Reducer	5 TEF
Trunk 10 ft	10 TEF
Better top t/o	40 TEF
6 inch run 15 ft	15 TEF
Angle Boot	30 TEF

Improved Return Ducts	
Return elbow	30 TEF
Elbow to trunk	30 TEF
Trunk 15 ft	15 TEF

Improved TEF of Duct

200 TEF

Media filters 4" - 5" MERV 8-11 have pressure drops of 0.15 IWC and stay "clean" for entire season (vs. 0.20-0.25 for 1" pleated)

HELP! How Can I Fix It?

New DPL = 0.25 coil + 0.10 filter + 0.09 R/G/D = 0.44

$$\text{Revised Friction Rate} = \frac{\text{New ASP } [0.70 \text{ ESP} - 0.44 \text{ DPL}] \times 100}{\text{New TEF}}$$

$$= \frac{0.26 \text{ IWC X } 100}{200 \text{ TEF}}$$

= 0.13” per 100 ft. of duct

Proper Trunk Size = 8” x 24” or 10” x 18”

HELP! How Can I Fix It?

Another Option: Move the furnace into the middle of the cellar…
You don't need the chimney anymore for venting!

- Now, the supply trunk is going in two directions, moving half the through two upgraded, supply trunks at 0.13 and 640 CFM
- Two 8" x 12" trunks could work; 8" x 14" or larger are better
- But, if the ducts are not upgraded :
  The F/R is still 0.07 for 640 CFM, and the trunks in each direction need to be 8" x 18" or 10" x 14"

HELP! How Can I Fix It?

The Best Option: *Do a Manual J Load Calculation*

The house may not need 80,000 btu-hr at 95% or 3 tons of AC!

If the Manual J at proper design conditions requires
52,000 btu-hr for heating and
24,000 btu-hr for cooling

The Ducts might already be the right size!

Let's do the design calculations with the Ductulator…..

HELP! How Can I Fix It?

$$\text{Heating CFM} = \frac{52{,}000 \text{ btu-hr}}{1.08 \times 55F} = 875 \text{ CFM}$$

Cooling CFM = 875-1000 cfm

2 ½ tons AC at 350-400 cfm/ton

Note: the ACCA Manual S equipment selection process typically requires a half ton larger system (at proper design temps in our climate) than the Manual J load

HELP! How Can I Fix It?

With the ducts improved to provide

Available Static Pressure = 0.26
Total Equivalent Feet = 200

$$\text{Friction Rate} = \frac{0.26 \times 100 \text{ ft}}{200 \text{ TEF}} = 0.13$$

To move 875 CFM at 0.13 requires 8 x 18 trunk
To move 1,000 cfm at 0.13 requires 8 x 20 trunk
1,000 cfm in 8 x 20 trunk moves at 900 FPM

Using the Proper Size Equipment for the House Fixed the Ducts!
With a better filter and minor duct repairs, they will work!

Always do a ***Manual J*** load Calculation before replacing the system!

What Happens if I Don't?

Undersized ducts, restrictive air filters, and ECM's can be an expensive mis-match!

1. A variable speed, ECM will use as much power as it needs to satisfy the speed selection made by the installer

2. Undersized ducts will have high Total Static Pressure (TSP) and ECM will increase the power used as the TSP increases, which happens when the pleated filter loads up over time

The variable speed motor can eventually use 2-3 times more electricity than the old PSC motor and draw enough power to cause premature motor failure!

Summary

1. *Take the Blood Pressure of the Duct System!*
   Measure Duct Static with a Manometer and Static pressure tip

2. Look for ways to reduce the TEF on a replacement job.
   Show the customer where the problems are and the simple solutions.
   Better fittings ease the path for air to travel

3. Sell Media filters! Eliminate the one inch filter option, as they get dirty quicker and use more power as the ECM adjusts to deliver full airflow.

4. Identify ways to use rebates from ***CoolSmart*** and ***GasNetworks*** to reduce the customer cost to install the new system properly.

5. Become a ***CoolSmart QIV Contractor*** to maximize your profits and separate your company from others selling just on price!