

Airflow Is Critical To HVAC System Performance

By, Chris Van Rite, M&M Manufacturing Co.

Q. Does “Air Flow” really make a difference in HVAC system performance?

A. Absolutely! Equipment SEER is based on the manufacturer’s efficiency rating with no resistance factored in for the duct system. A bad duct system causes the equipment to work harder and less efficiently.

Q. If a duct installation passes inspection, is it a good duct system?

A. Not necessarily. Most building codes fail to address air flow. A duct system with terrible air flow can pass code inspection in many cities as long as it is properly sealed and insulated. Too many contractors assume that if they install duct as their competitors do and the job passes inspection, it must be a good duct system. It is important to realize that when we depend on code inspections to set the benchmark for good and bad, we are building to the lowest level allowed rather than the highest possible quality.

Few people would argue that the quality of all materials and workmanship is better in new homes today than it was 30 years ago. Market pressures force contractors to look for ways of cutting costs often at the expense of quality and performance. One of the casualties of this trend has been the HVAC duct system. Technology and higher federal standards have brought about significant improvements in HVAC equipment, but the quality of duct systems and overall system installation has declined.

Founded in 1991, the Consortium for Energy Efficiency (CEE) is a non-profit, public benefit corporation that actively promotes the use of energy-efficient products and services. CEE reports that according to recent research, “most residential central air conditioning systems are not installed properly”. This not only increases energy use but also reduces comfort and contributes to peak demand for electricity. Here is a breakdown of major problem areas and the frequency with which they occur:

- Over sizing of equipment - 47 %
- Inadequate airflow - 70 %
- Improper refrigerant charge - 44 %

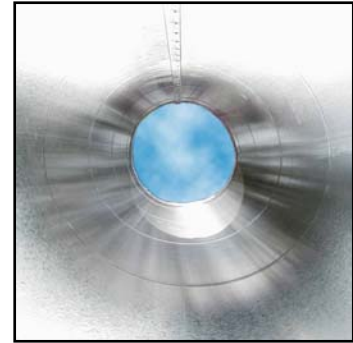
Correcting these problems could reduce air conditioning peak demand by 14 percent in existing homes and 25 percent in new construction. Proper installation and maintenance could also reduce air conditioning energy bills by an average of 24 percent in existing homes and 35 percent in new construction. *Consortium for Energy Efficiency (CEE)*





The True Cost of Flex

Trade-offs Between Material Cost and Performance



Flex is cheap and easy, but because of its spiral wire helix construction, flex duct has the highest friction loss when compared to Sheet Metal Duct or Fiberglass Duct Board. The inner core of flex changes shape with compression and bending, which increases turbulence and friction loss. Unfortunately compression and bending are the very attributes that make flex duct so popular. A good example of how easily flex is compressed can be found in the factory packaging. Twenty-five feet of 8" R-6 flex can be packed into a shipping bag that is only about 22 inches long.

It's no surprise that installers prefer flex. Because it is soft and flexible, installers find it easy to squeeze flex through tight places, kink it around corners and compress excessive lengths between fitting connections. The result is a duct system that reduces equipment efficiency and costs the homeowner hundreds of dollars more per year and thousands of dollars over the life of the system in higher utility bills.



Lower cost and ease of installation have made flex quite popular particularly in Southern and Western states. Contractors and builders have discovered that a flex duct system can be installed just about anywhere with little or no accommodation in the framing or the design of the home.

Some states restrict the use of flex to 5 feet or less at the end of a sheet metal duct run. This forces contractors and builders to work together to accommodate a proper duct system. But in states where flex is allowed to be installed without restrictions, a disturbing trend has developed toward bad installations and an apparent disregard for airflow.

The Air Diffusion Council (ADC) is an association of manufactures of flexible air duct. ADC publishes an installation guide titled "Flexible Duct Performance & Installation Standards". The following excerpts warn the installers of the dangers of installing flex inappropriately.

"The number of bends, the number or degrees in each bend and the amount of sag allowed between support joists will have serious effects on system performance due to the increased resistance each introduces".

"Install duct fully extended, do not install in the compressed state or use excess lengths. This will noticeably increase friction losses".

The Air Diffusion Council - "Flexible Duct Performance & Installation Standards"



Higher Friction Loss = Less CFM (volume)

When less air is delivered, the system has to run longer to achieve the desired comfort level.

Airflow problems have plagued the HVAC industry for years. Unfortunately some contractor's remedy for poor airflow has been to oversized equipment rather than to address the root problem. Design tools such as the friction loss tables in ACCA Manual "D" and "Ductulators" are used to size ducts to deliver the desired amount of air, but these design tools assume certain installation standards some of which date back to the 1950s. As the quality of modern duct installations has declined, the design tools don't always correlate with installed duct performance.

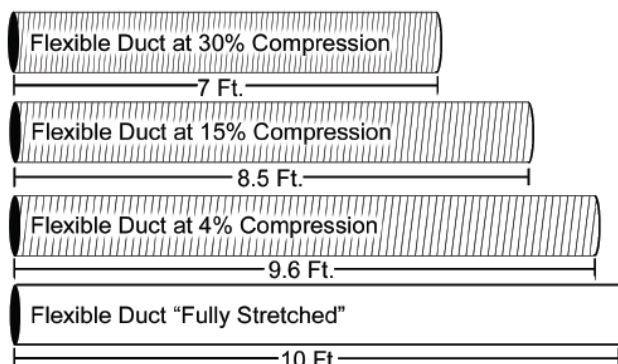


In 2002 a comprehensive review of airflow in HVAC duct was commissioned by the Air Distribution Institute in cooperation with ASHRAE and other co-funding partners. The Energy Systems Laboratory (ESL) at Texas A&M University undertook this research in order to verify the accuracy of the Manual D friction loss tables and to assess whether the test methods used to gather friction loss data appropriately relate to modern installation practices.

The ESL research concluded that when following test protocols prescribed by ASHRAE, the Manual D friction loss tables and therefore the ductulators that correlate with Manual D are accurate for both round metal duct and flex. However when flex was tested under "As Built" conditions such as we see in modern installations, friction losses increased as much as 10 times higher than predicted by Manual D. A similar study conducted by Lawrence Berkeley National Laboratory found very similar results.

The prescribed method for testing air flow in flexible duct requires that it be stretched tight and released on a flat surface. This results in the flex resting at approximately 4% straight line compression. Air is then forced through the test duct section and sensors record pressure loss. The problem is that flex is rarely installed in a straight line and stretched as in the prescribed test method.

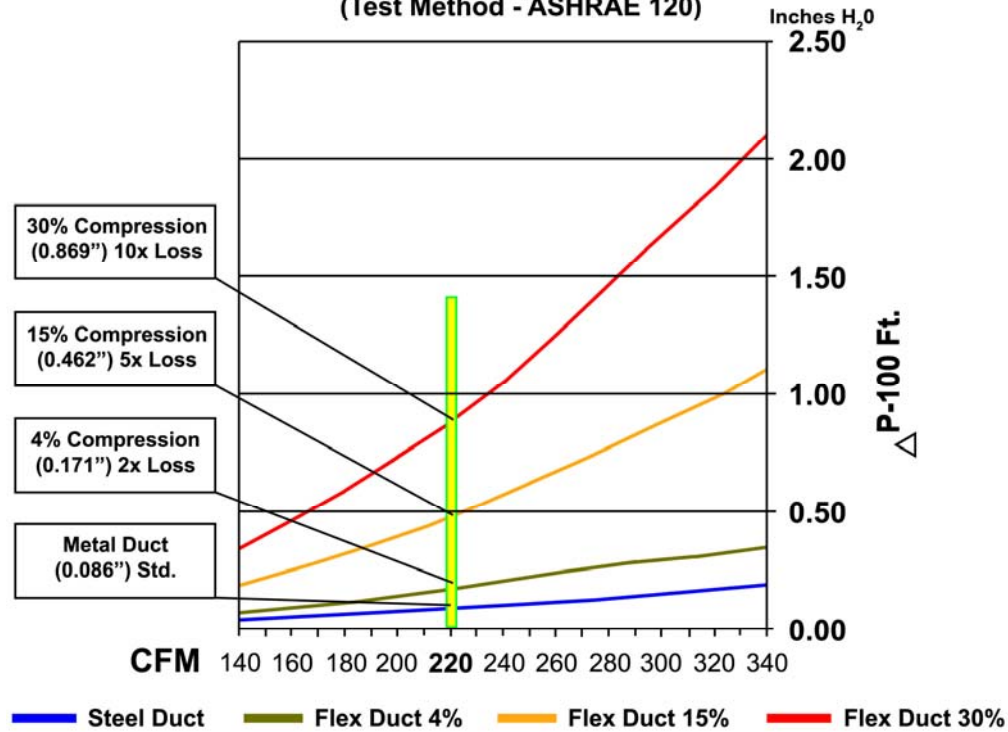
One common mistake made by installers is not cutting off excess lengths of flex duct before making connections. This practice compresses the installed flex into a shorter length much like an accordion. The amount of compression in flex duct is described as a percentage of the stretched length. Example: A length of flex that measures 10 feet long when fully stretched, but installed such that it is 7 feet long results in 30 % compression.



This graphic depicts flex at various rates of compression and shows there is little difference in appearance between fully stretched flex and compressed flex.

ESL researchers investigated the affects of straight line compression in flex duct and found that even small amounts of compression dramatically increase friction loss.

Static Pressure Losses 8" Sheet Metal Duct vs. 8" Flexible Duct (Test Method - ASHRAE 120)



It has long been an accepted practice to upsize one diameter when using flex instead of metal duct. ESL research found that when installed at as little as 15% straight line compression a 10" flex duct is required to be equivalent to an 8" metal duct.

Compression is just one installation variable that increases friction loss in flex. Besides excessive bending and crimping, installers often find it easier to simply use up the piece they have rather than take the most direct route and cut off the excess. This is a waste of material and needlessly adds additional length and friction loss to the duct system.



Because too many contractors and builders do not realize the impact of using a less efficient duct material and then installing it poorly, these problems will likely continue until code bodies, energy saving programs and state and local amendments address the problem and restrict the use of flex duct.

Conservation Services Group (CSG) currently administers a wide range of new construction programs in various states including ENERGY STAR® Qualified Homes programs. In 2000 CSG published "ENERGY STAR HOMES Technical Standards" which makes the following recommendations. "Avoid flex duct whenever possible. If flex duct is used, be sure to include the extra friction losses in your system design. Flexible duct runs longer than 5 ft. can severely restrict airflow. Keep flexible ducts as short and straight as possible".

ASHRAE has recently published Advanced Energy Design Guides for “Small Office Buildings”, “Retail Buildings” and “K-12 School Buildings”. The goal of these publications is achieving 30% energy savings. The design guides make the following recommendations regarding flexible ducts.

Flexible ductwork should be of the insulated type and should be as follows:

- Limited to connections between duct branch and diffusers
- Limited to connections between duct branch and VAV terminal units
- Limited to 5 ft (fully stretched length) or less
- Installed without any kinks
- Installed with a durable elbow support when used as an elbow
- Installed with no more than 15% compression from fully stretched length *

** “Retail Buildings” & “K-12 School” design guides were published after “Small Office” and include the above text regarding 15% compression*

Homeowners Want Performance and IAQ

Of the three major types of duct material, sheet metal duct still provides the most durable, efficient and clean air distribution system. In addition to offering superior air flow, the easiest way to install sheet metal duct is in a straight line, so installers tend to limit the number of turns and to plan them such that each run can go as far as possible before changing directions. The result is a galvanized metal duct system with the fewest number of turns which limits friction losses and increases efficiency.



Zinc in the galvanized coating of sheet metal duct actually kills mold and gives excellent protection against all types of organic growth. This can be very beneficial as we have discovered in recent years.

Duct systems do need cleaning occasionally and the hard, smooth surface of sheet metal can be cleaned and maintained far better than non-metallic duct materials.

Hybrid Duct Systems

Because sheet metal duct is hard and smooth, it conducts air very efficiently. It also conducts sound efficiently. Flex duct has a rough surface, so it isn't the most efficient way to move air, but it does have superior sound attenuating qualities.

As in states where the use of flex is restricted, many contractors have found that the best of both worlds is to run a predominantly metal duct system and install a short length (3 to 5 feet) of flex at the end of the duct run. These “Hybrid” duct systems maximize the efficiency of metal duct while using the convenience of flex to make the final connection to the register box and minimize HVAC system noise.



Until recently the trend in new construction HVAC duct products has been towards variations that were faster, cheaper and easier. These “easier to install” products lend themselves to using lower paid and lower skilled labor and this too has contributed to a host of installation related problems. With rising energy costs and a growing awareness of indoor air quality, homeowners are insisting on clean comfortable and healthy living space with affordable utility bills. Installing a sheet metal or Hybrid duct system as an upgrade is an excellent way of fulfilling these requirements.

Regardless of the materials used, proper duct sizing and installation are critical to system performance and therefore energy efficiency. As the demand for more energy efficient homes increases, there will be excellent opportunities for HVAC contractors who offer higher levels of products and services and this usually equates to higher profits.

Reference Materials

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ASHRAE Advanced Energy Design Guide for “Small Office Buildings”, “Retail Buildings” & “K-12 School Buildings” available currently as a free download from ASHRAE Publications Store

<http://www.ashrae.org/>