GOING WITH THE (AIR)FLOW

There are several methods you can use to measure residential system airflow

BY BILL SPOHN & BRYAN ORR

Q&A

Bryan Orr and I decided to partner on this article, and we will do it in the manner of a virtual Q&A session. We always have good conversations!

Q: Why is setting the correct system airflow so important?
A: There are several reasons driving the need to get system airflow set correctly. The most basic one is to get the system delivering the needed capacity. Air based systems use air as the heat transfer media (both sensible heat and latent heat).

And it is really the mass flow of air (pounds of air) that does the work. If you are looking to have the system perform as intended it must be moving the correct mass flow of air that is in balance with the refrigerant charge for cooling and the heat exchanger output for heating mode.

We usually express this mass flow of air as cubic feet per minute, or CFM, of airflow.

When the airflow is in balance with the charge/heat output, this can help to prevent evaporator freeze ups, heat exchanger burnouts or high limit trips. The known/proper amount of system CFM is your sum total to work with to achieve proper space conditioning throughout the space via the distribution system (ductwork). It is essential to know how much you have to start with to then compare with what you measure at the supply and return registers to get a handle on duct leakage. Additionally, if zoning is employed, understanding the necessary flow to zones and possible bypass amounts is helpful.

Q: What is the difference between static pressure and velocity pressure?
A: Static pressure is the inflation pressure within a duct; we also refer to it as balloon pressure. Others refer to it as the blood pressure of a system. Static pressure pushes in all directions in the duct. Velocity pressure is the pressure of the air in the duct due to the speed of the air. The total pressure is the sum of the static pressure and the velocity pressure. The air distribution

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Hot wire anemometer.
blower has a maximum total pressure that it can produce. If components in the system (coils, heat exchangers, filters, non-stretched flex, poorly-sized ducts, etc.) cause “drops” in static pressure, air velocity, and hence system performance, will be impacted.

Additionally, looking at the total external static pressure (TESP) (the sum of the supply side and return side static pressures outside of the air handler/furnace) can be used to diagnose where excessive pressure drops in the system are located. A helpful hint from Corbett Lunsford (www.HomeDiagnosis.tv) is that static pressure measurements are like a spotlight pointing away from the fan, allowing you to “see pressures” that are away from the fan.

Static pressure is measured with a probe called a static pressure tip. It’s an L-shaped rigid tube that has a closed tip that is designed to face into the air stream. The open end of the tube is connected to a pressure gauge (manometer) with an appropriate range and resolution for the task at hand. There are several holes along the periphery of the tip of the tube that pick up the static (balloon) pressure and conduct it back to the manometer via a hose.

**Q: How do I convert static pressure to velocity?**

**A:** It is not possible to convert static pressure to velocity. You might be thinking of using a Pitot tube that measures both total pressure and static pressure. A static pressure tip is sort of like “half” of a Pitot tube in that it only measures static pressure. When you subtract static pressure from total pressure you get velocity pressure, as noted before. To get the actual air speed or velocity, you need to run the velocity pressure from a Pitot tube through the Pitot equation to get air velocity.

The Pitot equation does involve a constant that is dependent on air density yet air density changes whenever air temperature, humidity, or barometric pressure changes. Additionally, the Pitot tube only has the ability to know the total pressure (and hence the velocity pressure) at its tip. Therefore, it must be “walked” or traversed across the duct to determine the average velocity by taking multiple samples across the area of the duct.

**Q: How do I convert static pressure to CFM?**

**A:** Many manufacturers provide equipment-specific tables that compare the static pressure drop across certain components to the airflow in CFM that induces that static pressure drop. You’ll need two static pressure tips, some hose and a manometer to do this test. This can be very practical to determine ballpark airflow in CFM. I say ballpark, as the table usually provides resolution in steps of 50-100 CFM for each 1/10th of an inch of water column in static pressure drop.

It is important to note that this process involved replicating in the field a test that was done in the manufacturer’s lab. Challenges are introduced with systems that are not in the same condition as what they were when tested in the lab during the development of the chart. Even with new systems, be sure to note if the chart describes a wet or a dry evaporator coil. Or, if the pressure drop is to be measured around the evaporator coil, the heat exchanger or both.

Further, when testing previously installed equipment, dirty coils and dirty blowers will all make this measurement less precise. Testing with replacement blower motors, unless identical to the factory motor, make this measurement useless as the motor characteristics play a part in the static pressure generated.

Speaking of motors...since Electronically Commutated Motors (ECM motors) provide more consistent CFM levels across a broader range of total external static pressures, you won’t see a lot of variation in the manufacturer’s CFM vs. static pressure. ECM motors do require proper setup in controls (motor taps or board pin/selector settings) to produce the required CFM output.

So, ECMS are only as good as how they are setup. It is also important to note that while ECMS provide the designated CFM they are set for in spite of the TESP, they do so at the expense of power, sometimes consuming almost three times as much power across a range of TESPs from low to high.
Q: What are some of the methods for measuring system air velocity?

A: There are four methods for measuring system airflow that give direct output in CFM and three methods that give output in velocity.

If the CFM method you choose gives you velocity, you'll need to know average velocity and the cross-sectional area of your measurement location to determine the CFM. Average velocity is determined by locating a probe in specified places in the duct in a method known as a traverse using either a timed average or a point average. TruTechTools Ltd. has prepared a simplified chart based on the National Environmental Balancing Bureau’s traverse guidelines for rectangular ducts. You can download the Rectangular Duct Traverse guide here: www.trutechtools.com/Resources.

The CFM is equal to the average velocity (in feet per minute) multiplied by the cross-sectional area in square feet. Cross-sectional area is determined by taking the inside dimensions of the duct.

If a rectangular duct, multiply the width and depth in inches, then divide by 144 to get square feet.

The three velocity yielding measurement methods are the Pitot tube, hot wire and rotating mini-vane. We have already covered the Pitot. The rotating mini vane and the hot wire work in a similar way in that they only know the air velocity at their probe tip and need to be traversed across the duct. Some of the meters that you use with a Pitot tube, hot wire and rotating vane will do the averaging during a traverse and even do the cross-sectional area computation, if you give it duct dimensions.

The four methods that yield CFM directly are the previously noted static pressure tips (with manufacturers’ charts), temperature rise method, the Duct Tester Pressure Matching Method and the TrueFlow® grid made exclusively by The Energy Conservatory.

As simple as it seems, the temperature rise method present several challenges:

- Knowing energy added to heat the air—with a heat strip this is easy, but this can be a challenge for a fossil-fueled system, as you need to do a combustion analysis too!
- Getting the correct temperature with a good resolution temperature meter
- Correcting the sensible heat equation (factor) for air density
- Accounting for temperature gain from motor heat
- Avoiding the heat gain on your temperature probe from radiant surfaces inside the equipment—after all you want to measure only air temperature
- Repeatability of your temperature meter
- Waiting for sufficient stabilization time if the system had been running in cooling mode and the coil is wet

Orr’s HVACRSchool.com has a great blog post delving into this issue (www.bit.ly/TempRise). The Minneapolis DuctBlaster pressure matching method involves matching the normal system operating pressure of the air handler (from a static pressure tip) using an externally connected variable speed fan (Duct Tester), which has its own integrated CFM measuring device.

Set up is important: Turn off the air handler fan and open a window or door between the building and outside to prevent pressure changes in the building during the test.

Also, make sure all supply and return registers are open and uncovered (un-taped). System air filters should be replaced if they are dirty (or keep dirty filters in place if you want to measure flow in an “as found” condition).

This test can be performed at the air handler cabinet (by fashioning a custom cabinet interface so that the duct tester’s hose can be attached). Or testing can be done if there is one central return.

The TrueFlow® Grid is used to get direct system CFM by inserting a test plate (the grid) into the filter slot. The grid has a Pitot tube array.
A: It’s possible to use a balometer for system airflow measurements, since a system’s air is pulled in through a return (or returns) and delivered through the supplies. It follows that the total supply flow should equal the total return flow. And they both should equal the total system flow.

Q: Can you use a flow hood (balometer) for system airflow measurement?

However, you will be making three big assumptions: 1) there is no duct leakage 2) your balometer is yielding accurate results and 3) using your balometer is not causing an insertion loss and “messing” with the system flow due to the back pressure possibly caused by making a measurement. airflow measurement is a complex topic, so do not be frustrated if it takes time to understand and learn the correct methods.

If you wish to explore further, video resources are available at this link: www.bitzly/TruAirFlow. Remember to go with the flow.

Bill Spohn P.E., a frequent webinar presenter for RSES, is president and CEO of Tru-Tech Tools Ltd. Bryan Orr is the co-founder of Kalos Services, a multi-discipline HVACR contractor in Central Florida and Founder of HVACRSchool.com and the HVAC School Podcast.