

PRESSURE-TESTING Ductwork

A pressure test with telltale fog will keep your duct installers on their toes

Airtight ductwork is one of the keys to a quality heating and cooling system. It helps to make a home more

by **Michael Uniacke**

healthful, more comfortable, and more energy efficient. By reducing the load on the equipment, it also reduces wear and tear.

There is only one way to make sure that the ductwork has been thoroughly sealed: Test it. A simple pressure test can measure the airtightness of the air distribution system and helps you hold your installers to a high standard of quality.

Of course, airtight ductwork is only one of the keys to quality hvac. A *Manual J* load analysis and *Manual D* duct design, proper refrigerant charge, and correct airflow over the evaporative coil are all just as vital. But poorly sealed ductwork can negate good work in all those other areas: You can properly size the unit, lay out the distribution system correctly, tune the compressor perfectly, and set the fan



just right, but if leaky ductwork blows most of your conditioned air into the attic, or pulls most of the system's return air from the crawlspace, you'll have a system that costs too much to run and doesn't do its job.

Pressure testing is not a new concept in home construction. Plumbers have

their work pressure tested on every job, and the test forces them to get it right — meaning no leaks, period. But when plumbing leaks, there is an immediate consequence: Things get wet. Air leakage, on the other hand, is invisible and seldom causes immediate trouble. Instead, homeowners gradually become

Figure 1. The Minneapolis Duct Blaster is a calibrated variable-speed fan that's tied into the heating or cooling air distribution system at a supply plenum, return grille, or air handler compartment (right). The digital pressure gauge (below) calculates air leakage rates from pressure and fan speed data.



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aware of comfort problems, high utility bills, and decreasing indoor air quality over time. The test is the only way to identify the defects in advance.

In ten years of testing ductwork before drywall is hung, I've seen some excellent ductwork installations and some atrocious ones. I've learned that if you want consistently good results, you have to test consistently. All tradespeople do better work when they know they face inspections. As one local mechanical contractor's lead man put it to me, "There are three kinds of air distribution systems: regular, sealed, and sealed and tested." If you test your installer's work, it will get better. And realistically, until you start testing, and showing your installers the results, they won't even know that their system leaks. They certainly won't know where it leaks. The test makes them face reality, but it also helps them learn.

The duct airtightness testing system I use is called Minneapolis Duct Blaster, from the Energy Conservatory

(612/827-1117, www.energyconservatory.com). It consists of a calibrated variable-speed fan, a fan speed control, and a digital pressure-reading gauge called a digital manometer (see Figure 1). The test itself is pretty simple: We attach the Duct Blaster fan to the air distribution system at a return grille, a supply plenum, or the blower compartment on the air handling unit. We temporarily seal off all the registers and grilles. Then we turn on the Duct Blaster fan and apply pressure. The Duct Blaster system measures the airflow needed to create a test pressure of 25 pascals (a 0.10-inch water column) in the duct system. This airflow rate is our duct leakage measurement. We compare the duct leakage reading with a recognized standard, and we give the system either a pass or a fail. The whole process takes less than two hours (mostly for setup and takedown) and typically costs around \$220.

Over the years, my company has headed off a lot of potential problems by testing ductwork before the drywall is hung. When the drywall is up, we can

still gain access to the ducts, but the problems are harder to locate and assess.

Why Airtight Ductwork Matters

Good duct sealing makes a major contribution to the healthfulness, safety, comfort, and efficiency of a new home. Sealing the ducts is even more important than sealing the building envelope, because when the air handler is running, the pressures in the air distribution system are much greater than in the building or the outside air. Pressure differences are what drive infiltration; a hole or crack in the building envelope is not an air leakage point unless it sees a pressure. Ducts always operate under pressure, so a hole in the ductwork is always a leak.

To clarify the importance of pressure, let's look at some numbers. Wind, stack effect, exhaust fans, and the like generate air pressures across the building shell that range from 0.5 to 10 pascals. On average, a house is usually in the low end of this range. (A pascal is a very small metric unit of pressure. There are 25 pascals in $1/10$ inch of water column. If you were to put a straw into a glass of water and suck the water up the straw 1 inch, you'd create an inch of water column pressure, or 250 pascals.)

Pressures created in air distribution systems when the air handler is running range from 10 to 125 pascals, tens of times greater than the ordinary pressures acting on the house envelope. And these pressures, unlike the wind, are continuous when the air handler is running. That is why house infiltration rates can double or triple when the equipment is active.

Temperatures. Remember, too, that leaks in supply ductwork involve conditioned air, not room air. The air that escapes from supply ductwork has been heated to 140°F or cooled to 58°F, and it is not getting to the room it was meant for. If most of the ductwork is in the attic or crawlspace (which is often the case), all this heated or chilled air is now leaking straight to the outdoors. The resulting

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energy loss is much greater than the loss that occurs when 70°F room air leaks out around a window, for example. That's why simple duct tightening may cut heating and cooling costs by 15% to 30% in many homes.

Duct leaks also typically affect comfort, because the system doesn't deliver the intended amount of conditioned air to satisfy the design load for a room. Rooms at the end of long duct runs suffer the most: The farther away from the fan a room is, the greater the likelihood that air will find its way out of a leak instead of going where it's meant to.

On the return side of the air distribution system, leaks pull ambient air or even hot attic air into the system, further compromising efficiency. Leaks also threaten indoor air quality: Air from a crawlspace may carry pesticides, moisture, radon, and mold spores, all of which can get sucked into the return leak, then sent through the supply side to every room in the house.

Energy penalty. How much do these leaks affect energy consumption? A 1999 summary report of 19 separate studies from around the country (www.aceee.org/pubs/a992.htm) suggests that the average annual energy

savings potential in a typical house from sealing the ductwork is around 17%. These studies include both heating and cooling climates. Anywhere ductwork can leak outside of the house, there is the potential for a large energy penalty. In one study, researchers at the Florida Solar Energy Center found that sealing ductwork in existing homes cut cooling bills by about a third.

Locating the Leaks

Where are these leaks happening? Basically, leaks are possible at any joint or seam in the system, from the air handlers supplied by manufacturers, right on through to the sheet-metal supply boots your installer brings to the job. If you look at all the joints, you'll find the leaks.

There are leaks on sheet-metal trunk ducts every 48 inches, where the trunk sections connect. Every collar attached to the trunk, where flex duct branches take off, represents a possible leak. So does every adjustable elbow. We also find leaks where flex duct connects to supply boots, in the boots themselves, and around the plaster grounds. I'm often surprised by how leaky some of the manufacturers' mechanical units are. I've tested units that leaked 40 to 45 cfm right out of the box.

I used to commonly find flex ducts that either had never been connected or had been accidentally disconnected by another trade. During the early to mid 1990s, most framed return cavities were major leakage sites. Disconnected ducts and framed cavities still tend to be the biggest culprits, but practices have improved significantly.

Stud and joist bays used as returns are still common in my part of the country and often present a lot of problems. All framed cavities should be lined with OSB, plywood, duct board, drywall, or sheet metal and then sealed with mastic at every joint. Hvac contractors sometimes blame the framers for not lining the cavities, but we don't accept that excuse — if it leaks, you fail.



Figure 2. The author tapes a plastic transition fitting to a piece of cardboard cut to fit the opening in the air distribution system (above), then places the assembly in the opening (above right) and connects the fan to the opening with a length of flex duct (right). It's best to test the system with the air handler installed, because the air handlers are often a leakage point. If the air handler has not been set, the author hooks up the Duct Blaster to the trunk line where the air handler will go. The equipment can also be attached to a return grille (below).



The most frustrating leaks are where the hvac installer tried to seal the system and failed — where someone did the sealing but didn't get it right. For example, it hasn't yet dawned on everyone that each joint and seam have to be sealed on four sides, not just three. If a crew hasn't had the benefit of some training, and has never seen a system tested and fogged, it's a good bet the system won't pass. Installers just can't picture the consequences of an average duct sealing job.



Running the Test

A Duct Blaster test on a single air distribution system takes about 45 minutes to 1½ hours to perform. Most of that time is spent sealing off registers and grilles and setting up the equipment. Once a system is prepared, it takes only about 2 minutes to perform the test.

The first step is to attach the Duct Blaster fan to the air distribution system (Figure 2). We can attach it to the blower compartment on the air handler or to a return grille. If the air handler is not set when I arrive to test, I connect the Duct Blaster directly to the trunk lines in the mechanical room where the



Figure 3. The author carries a roll of adhesive poly Duct Mask on his belt (left) and uses the material to seal registers and grilles (right).

air handler will eventually be set. But we prefer to test with the air handler installed, because of the leakage we've seen in even brand-new units.

The second step is to seal off the air distribution registers with a poly product called Duct Mask (Figure 3). It comes on a roll (also from the Energy Conservatory), so I simply run a belt through the roll and wear it around my waist. Duct Mask is perforated every 4 inches and has adhesive on one side. It makes sealing up the system such a simple task that I consider it essential. But I now have some mechanical contractors who seal all the supply registers that are installed in floors with sheet metal and mastic. This keeps construction debris and rain out of the ductwork and also prepares the system for testing.

The last piece of equipment to hook up is the digital manometer, which is simple to set up and operate. The digital manometer I use both measures the pressure in the duct system and directly displays air flow through the Duct Blaster fan in cubic feet per minute, which is convenient and cuts down on errors.

I can often tell how leaky a duct system is simply by turning on the Duct Blaster and seeing how quickly or slowly the duct reference pressures respond. A leaky system will require that I ramp up my Duct Blaster fan speed to overcome the numerous leaks in the system. In fact, in some homes the ducts are so leaky that I can't pressurize the air distribution system at all. In a system with a return that leaky, it's very possible that more air is being drawn into the system from the crawlspace or attic than is being pulled from the house.

Once the air distribution system is pressurized to 25 pascals, I read the air flow through the Duct Blaster fan from my digital manometer.

It's important to recognize that the Duct Blaster measures the air leakage at a test pressure of 25 pascals, not the actual duct leakage when the system is running. The actual duct leakage under normal use depends on where the leaks are located and what pressures they see. The closer the duct leaks are to the air handler fan, the higher the pressures. The typical leaks where refrigerant lines enter the coil, for

example, will see much higher pressures than the leaks around the supply boots at the end of branch runs, and thus will leak more air.

The tests are performed at a uniform pressure of 25 pascals because that represents a typical average operating pressure in residential systems and gives us a quick way to compare the measured leakage rate to accepted standards.

The Fog Machine

The shortcoming of a digital manometer readout is that tradespeople can't picture the leakage; in their minds, that number is not associated with anything. Also, we still don't know just where the leaks are. By introducing theatrical fog into the system through the Duct Blaster, we can make most of the leaks visible (Figure 4, next page).

The fog pouring out of duct leaks is a real eye opener. No one argues with this part of the test. Even after ten years of using a fog machine out in the field, I'm shocked sometimes that so much fog can leak out so fast. It is truly telling.

In my experience, installers really



Figure 4. When a system exceeds the allowable air leakage standard, the author uses a theatrical fog generator to introduce visible vapor into the Duct Blaster fan intake. The fog makes it easy to find the leak locations.



appreciate being on hand when their work is tested and fogged. It's often the first time they've seen their work tested, and the fog drives home the importance of paying attention.

Sealing the system. Fortunately, duct leakage problems are simple to eliminate during new construction if you know where to look for leaks and how to seal them. The cost varies depending on the system's size and complexity, but most systems can be sealed for somewhere between \$150 and \$600. Research has shown that the cost is recovered within one to five years; after that, the savings go to the homeowner's bottom line. And of course, the greatest benefit is a more healthful and comfortable home.

The products of choice are water-based mastic, accompanied by a fiberglass mesh on larger holes. The mastic has the consistency of mashed potatoes. It is easily spread over joints in the ductwork with an inexpensive paintbrush or one's hand. On cracks and gaps wider than 1/4 inch, a 2-inch fiberglass mesh tape is placed in a bed

of mastic to reinforce the seal. The advantage of mastic over duct tape is that it provides a long-term durable seal. The water-based mastic cleans up easily with water.

Duct Tightness Standards

The goal of duct sealing is to ensure that the system is sufficiently airtight. That does not mean submarine airtight or hermetically sealed. We aim not to eliminate leakage entirely (although some contractors come close) but to reduce the leakage to an acceptable threshold. I use one of two standards for duct system airtightness, and each generates a "not to exceed" duct leakage number.

One standard is 3% of the livable square footage. For example, a 2,000-square-foot home should have no more than 60 cfm of leakage in the air distribution system. The other common standard is based on the size of the air-conditioning unit, which you can read off the unit's label (or the installer can tell you). It's common practice to assume 400 cfm per ton, so a 4-ton unit would be rated at 1,600 cfm; the air leakage should not exceed 5% of the total airflow capacity, or in this example, 80 cfm.

These levels are realistic on the job; conscientious workers can easily satisfy them. In my experience, if a crew can't meet these criteria routinely, either they don't have enough training and experience, or they aren't trying hard enough.

Who Should Test?

There are a growing number of third-party testing companies like mine. A list of testing contractors by state is available on the Energy Conservatory website (www.energyconservatory.com).

I believe that hvac companies should conduct in-house testing of air distribution systems. If your hvac contractor already owns a Duct Blaster and other diagnostic tools, that tells you that the company truly wants to do quality work. Companies that don't own a Duct Blaster have to ask someone else

to test their work, as well as show them their mistakes.


I've worked with architects who make the builder pay for the first test and the hvac contractor pay for the second test if he fails the first one. If a system fails, as a part of my fee, I'll spend up to an hour on the job helping the crew find the leaks with my Duct Blaster and fog machine.

Reaping the Benefit

On most jobs, there is a tug of war between quality and profit, and profit routinely wins. This means ductwork is often not sealed, or it's sealed but not tested. When customers have a comfort, air quality, or utility bill problem, it adds to their distress to learn that no one bothered to implement a simple quality-control step. They begin to wonder what other corners the builder cut.

I always advise my builder and hvac customers to at least offer sealed ductwork and testing. If you offer it and the customer turns you down, there's a record, in case of later complaints, that the customer chose low price over quality.

For builders who do test, we file a test report, which becomes a record for the house. I encourage my builder customers to use this report as evidence that they are truly committed to quality behind the drywall. If you seal and test ductwork and the contractor across the street doesn't, you have a better product, and you can use our documentation to build your reputation.

Satisfied customers also provide a marketing advantage. A customer who moves into a new home that is more healthful, comfortable, and energy efficient is more likely to tell friends that you are someone who builds a home that works. 

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Sources of Supply for Duct-Sealing Mastic

AM Conservation Group, Inc.
908/852-6464
www.amconservationgroup.com

Biddle Company
800/878-7876
www.trustsm.com

Carlisle Coatings & Waterproofing, Inc.
800/527-7092
www.hardcast.com

Carrier AeroSeal, LLC
800/772-6459
www.aeroseal.com
(aerosol duct sealing franchiser)

Ductmate Industries
800/245-3188
www.ductmate.com

Duro Dyne Corporation
800/899-3876
www.durodyne.com

Foster Products Corporation
800/231-9541
www.fosterproducts.com

McGill AirSeal Corporation
800/624-5535
www.unitedmcgill.com

Mon-Eco Industries, Inc.
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RCD Corporation
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Rectorseal Corporation
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www.rectorseal.com

Shelter Supply
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