



## Air Temperature Diagnostic Techniques

by Rob Falke

Have you ever been totally stumped by a system? You know, that feeling when you've performed the usual diagnostics, everything looks pretty close, but there's something going on that's eluding you? You feel frustrated, but at the same time, if you're good, the anticipation of the hunt begins to burn in your veins.

Load your quiver with some of these temperature diagnostic tests, and then stay sharp by using them regularly. Even seasoned technicians can pick up at least one new weapon from this menu of tests.

### ***Instruments***

The instruments needed to test temperature can be inexpensive and are available everywhere — a simple pocket thermometer can work miracles starting at \$10. High-tech infrared thermometers can be added to your arsenal for less than \$100, and state-of-the-art instruments are available for as little as \$300.

A number of temperature recording systems can be critical in some temperature diagnostic tasks. These range between \$50 and \$800. Most of these instruments download data to your computer for analysis and reporting.

### ***The Basics***

The most common testing includes measuring changes in air temperature over the heat exchanger or cooling coil. This is the reading that most manufacturers want when contacted about troubleshooting or warranty issues. While critical, these numbers only identify possible equipment deficiencies and rarely tell the whole story about the system.

Let's start with temperature drop. Temperature drop over a cooling coil normally ranges from 16F to 19F in humid regions of the southern and eastern U.S. In the arid west, you'll find good temperature drops run from 19F to 22F.

Temperature drop is usually affected most by the operation of the refrigeration cycle, airflow, and humidity. In fact, cooling temperature drop can't be interpreted properly without knowing system airflow. Ignoring system airflow is a common error.

On the other hand, temperature rise, which is affected by the performance of the burner, draft, combustion air, and airflow over gas-fired heat exchangers, normally ranges from 35F to 65F. Check the nameplate data on the furnace for the manufacturer's recommended temperature rise.

Keep in mind, if your diagnostics only includes equipment temperature changes, you'll rarely identify the real cause of the system problems.

True temperature diagnostics just begins with the equipment. The goal should be total system performance, not just answering the question, "Is the equipment working?"

### ***Begin The Hunt***

Now that you have an idea that the equipment is operating as it should, you're ready to leave the lodge and start the real hunt. Let's examine the ducting and see what it's doing. Assuming the duct system is working as it should is a mistake that many technicians make. Duct loss or gain should not exceed 3F.

**Supply ducts:** Drill a 3/8-in. hole in the supply plenum and measure its air temperature. Then measure the discharge temperature at the furthest supply grille. Subtract the supply plenum temperature from the grill temperature. This simple test takes less than five minutes and can be accomplished using a pocket thermometer.

*Heating example:* Let's say it's a cold winter day; the attic temperature is 40F. The supply duct insulation is R-4.2. The temperature rise over the heat exchanger is 40F. Additional measurements show that the supply plenum temperature is 120F and the supply register temperature is 110F.

Subtract 110F from 120F. The result is a 10F difference. In other words, this system is losing 10F through the supply ducts. This is not uncommon. Now divide the 10F duct loss into the 40F rise over the heat exchanger and you'll see that the system has lost 25% of its heat!

**Return ducts:** The same test holds true for return ducts. Only they're typically far worse because, during the summer months, they pull hot air from the attic directly into the system and building. This is why customers complain that the cooling system works OK in the morning, but not at all in the afternoon.

*Cooling example:* It's a scorcher, it's 100F outside and a day when the air conditioner is needed the most. It's 150F in the attic with 200 feet of poorly insulated supply ducting. The temperature drop over the coil is 20F. The supply plenum temperature measures 60F with the average supply register testing out at 70F.

Thus we see a duct temperature loss of 10F. Divide the 10F loss into the 20F temperature drop over the coil: the system is losing 50% of its capacity. That just turned the system's efficiency from 14 SEER to 7 SEER.

The hunt went well today.

Try this test even when you think the ducts are within the envelope of the building. You'll be surprised that often, they really aren't.

### ***Measure Percentage Of Duct Loss***

This is another test that only requires a pocket thermometer and a drill bit. Three measurements are needed to identify the percentage of system BTU loss in a return duct. Measure the average return air grille temperature (RAT). Let's say it's 78.2F. Now measure the mixed air temperature at the return plenum (MAT). For this scenario, let's agree that the reading is 94.5F. And finally, the measured air temperature in the attic outside or surrounding the ducting (OAT) is 140.5F. Apply the following formula:

With these three simple temperature tests and formulas, you just determined the percentage of Btu loss in this return duct.

The same formula works to find the percentage of outside air being pulled into a system. RAT is the temperature of the return air, MAT is the mixed air temperature in the air stream after the outside air inlet, and OAT is the outside air temperature.

## **System Performance**

Notice how these last few tests isolated duct system performance from equipment performance? Often, ducts have a far greater effect on system performance than does any high efficiency equipment.

In theory, 14-SEER equipment should increase efficiency by 40% over 10-SEER equipment. Here's the bottom line: By measuring temperature change (Delta T) over the equipment, we only see the functions of the equipment. To "see" the performance of systems as a whole, we should measure the difference between the average RAT and the average supply register air temperature (SAT). This test includes the ductwork in the formula, which has a significant influence on the system, especially when the ducts are located in unconditioned spaces.

Another test checks for a short cycling condensing unit that may have been installed under an overhang. Simply measure the air temperature entering the condensing unit compared to the ambient temperature in an open area 10 ft. or so away from the condensing unit. Ideally, both temperatures should be the same. If not, this means some discharge air is being pulled back into the condensing unit. This significantly reduces the condensing unit's capacity.

## **Measuring Btus**

If we add airflow to our testing process, we can field measure actual system Btu delivery. In the hunt for comfort, that's like graduating from a slingshot to a compound bow.

Sensible Btu is easy to measure and typically provides the information necessary to evaluate system performance. All you need to do is measure the volume of supply airflow entering the building (CFM), and the dry bulb temperature difference between the average RAT and the average SAT.

Remember, sensible Btus typically are 70% of total Btus or about 8,400 sensible Btu's per ton.

Check the manufacturer's cooling performance tables and plot the design sensible Btu (sBtu) under current operating conditions to increase accuracy.

Here's the sBtu formula:

$$cfm \times \text{The system temperature change (Delta T)} \times 1.08 = \text{Sensible Btu}$$

First lets look at a 4-ton system as the designer saw it:

$$1600 \text{ cfm} \times 20F \times 1.08 = 34,560 \text{ sBtu}$$

Now plug in some field-measured values and compare the design to actual sensible Btus. If the four-ton system only produced an airflow of 1,210 cfm and the system Delta-T was 15F, then our formula would read as follows:

$$1210 \text{ cfm} \times 15F \times 1.08 = 19,602 \text{ sBtu}$$

Now, by dividing the measured SBTU into the design SBTU, you'll find that this system is only delivering 57% of the sensible Btus that the building owner was promised when he bought the system.

*Field Measured sBtu 19,602 / Design sBtu 34,560 = 57%*

Traditional temperature testing over the coil may not have detected the problem. In that case, the unit would have been given a typical maintenance check-up and the service tech would have moved on to the next piece of equipment. And the customer would have continued living in an uncomfortable environment.

The next step in temperature testing is to measure the total, sensible and latent Btus that a system delivers — a process that calls for measurements of both entering and exiting wet bulb temperatures and the use of an enthalpy chart.

But that's for a future article.

The hunter's prize for this article is to think and test outside the box (the equipment). By doing so, you'll enjoy a new level of temperature testing and delight your customers by solving problems they've been forced to live with for years. n

**Rob Falke** is an industry author and trainer and has served his customers as an HVAC contractor and air balancer for over 20 years. He is the president of National Comfort Institute. He can be reached at [rob@ncinstitute.com](mailto:rob@ncinstitute.com). For a free procedure showing how you can field-measure HVAC system total, sensible and latent Btus call Rob at 800/633-7058.