

BY DOUG HORGAN

Monitoring Home Performance

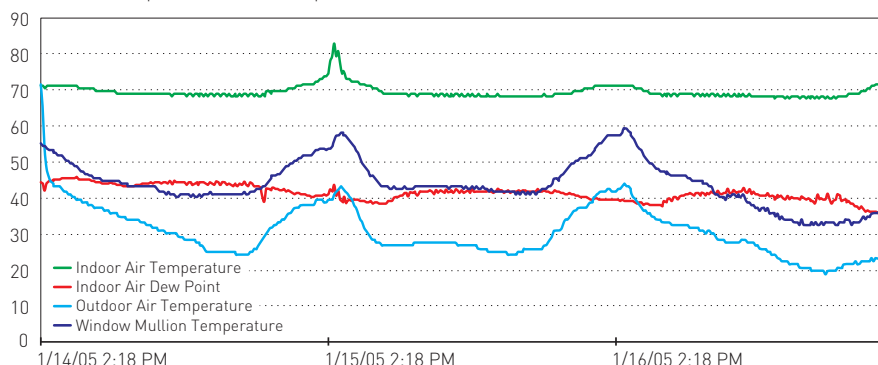
It started with a call from the homeowner saying the child's bedroom had been "freezing cold" that morning. But Bill, our heating subcontractor, said the bedroom was "fine"—within three degrees of the thermostat setting. The problem was that, by the time we drove out to the renovated house, it was 9:30 in the morning, 10 de-

grees warmer outside, and the bedroom door had been open for hours. The next day, we got the same call: The bedroom was too cold at 7 a.m. with the door closed. Our heating company was stuck in the rush of repairs that accompanies the first cold weather in fall, and once again couldn't get to the house first thing in the morning.

That's when we decided to buy some data loggers so we could see exactly what was happening. There are certain problems that are hard to catch because you may not be at the house when they happen. We've found data loggers to be invaluable for evaluating HVAC performance, condensation, and other temperature problems, especially when they are complicated or occur intermittently.

Window Mullion Temperature Below Dew Point

Whenever the purple line (window mullion surface temperature) dipped below the red line (indoor dew point), condensation would form on the windows. Reducing indoor humidity lowered the dew point and solved the problem.



MONITORING EQUIPMENT

I first bought my data loggers in 2001 from MicroDAQ (microdaq.com), which has provided great support. Besides the four original Onset HOBO H8 units, I bought a remote temperature sensor on a 20-foot wire that can measure air or surface temperatures. We also needed a compatible USB cable and software to launch and download the data. We've since bought another eight recorders directly from Onset (onsetcomp.com), so we can monitor several houses at a time or dissect complicated zoning problems that need multiple recorders.

The models we bought record temperature and humidity over an adjustable time

CASE STUDY: COLD WINDOWS

We had some beautiful steel casement windows installed by a factory crew on a large remodel. However, even during construction, we noticed condensation forming on them. The clients called us in a panic during the first cold snap of the winter. They woke to find the window frames coated with ice melting onto the wood floor.

The architect had specified these units for other houses without mishap, so he reasonably

thought that the installation might be at fault. Our HVAC contractor didn't think the humidification equipment was unusual either.

We set up recorders to measure indoor temperature, indoor humidity, outdoor temperature, and using the remote temperature sensor (1), the temperature of the window frame. When the next cold snap hit, we were able to show that the inside surface of the window frames was below freezing

when the outdoor temperature dropped below 20° F. Using the built-in features of the Onset software, we could show that the window frames dropped below dew point, even when outdoor temps were above freezing (see graph, above).

With this information, the conversation changed from an installation question to a humidity management question. Our HVAC contractor installed outdoor temperature sensors to turn off the humidifiers below

an adjustable point. We used the recorders to home-in on the proper set-point and to show the anxious homeowners that the dip in indoor humidity was brief and not too severe. A third-party engineer was brought in to consult. After seeing a graph of the frame temperature dropping below dew point, and even below freezing, he wrote a letter to all parties explaining that the recordings conclusively identified the problem and our solution was probably the best one.



1. A remote temperature sensor on the inside of a casement window records surface temperatures. **2.** This data recorder with a blinking LED has been placed in an inconspicuous location.

interval. At the 10-minute interval I most often use, our loggers will store 27 days of readings. This is almost always enough time for a cold snap or heat wave to reveal problem behavior in the house. The updated H12 model can record even longer.

Most recently we invested in a water flow meter and HOBO ZW loggers, which communicate wirelessly and can be read live over the Internet. The ZW system is more expensive and took a lot more setup than the standalone loggers, so we continue to use both types, depending on the situation.

PLACING SENSORS

A typical scenario is one room that overheats on a hot day but is fine most of the time. In a case like this, with one problem area, I would normally put one temperature/humidity recorder in the problem room, another near the thermostat, one outdoors to record the ambient temperature, and typically at least one more somewhere in the house—perhaps in another room that isn't having problems.

Keeping the recorders out of the sun is important. The recorders also have a blinking LED that can be annoying. For both reasons, I typically hide them behind pictures or books on shelves or tables (**2**). We also put one near the thermostat (but not on the thermo-

stat; some high-end communicating models can produce heat).

Onset makes special outdoor sensors with built-in shades to keep direct sun off, but I haven't bought any of these; I just put a recorder in a Ziploc bag and tape it somewhere on the north side of a tree or perhaps on a shady screened porch.

I'm always careful to make a list of which recorder is placed where. (I numbered ours with a marker when they first arrived.) When I use more than a few recorders, I take photos of where I've placed them. After two or three weeks managing 12 recorders, it can be difficult to find them all.

LOGGING DATA

Typically, I'll wait for the weather we need to get good information—in our typical scenario, a hot few days—before returning to collect the recorders. I connect them to a laptop on site and download the data. I use the Onset software to graph the data, which I find more digestible than the tens of thousands of data points. Sometimes I export the recordings into Excel if I want more graphing options.

The graph will show when (if ever) the room overheats—what time of day, what outdoor temperature, and what temperature the rest of the house is. Sometimes we find that the

CASE STUDY: HVAC ZONE WITH A MIND OF ITS OWN

In one house we renovated, there were eight zones on one air handler—leaving aside the other three air handlers—and it behaved oddly at times. The clients reported that the kitchen was often above set-point. This happened even in relatively mild, 80° F weather.

Using the data recorders set to measure every two minutes, we were able to see that the system would run all afternoon, trying to cool off the kitchen. The rangehood fan was broken and the clients preferred to leave all 23 recessed lights on

most days, creating a constant demand for air conditioning. Unable to satisfy demand, the system eventually would overcool other rooms (zone systems typically permit a bit of "blow-by"—air that passes the dampers), triggering the automatic thermostats to call for heat in those zones.

The zone-control board has a 3-minute purge cycle and a 20-minute changeover lockout, so once a zone calls for heat, it takes a minimum of almost half an hour before the system starts back to cooling. On 80° days, the kitchen would stay near the set-point until other

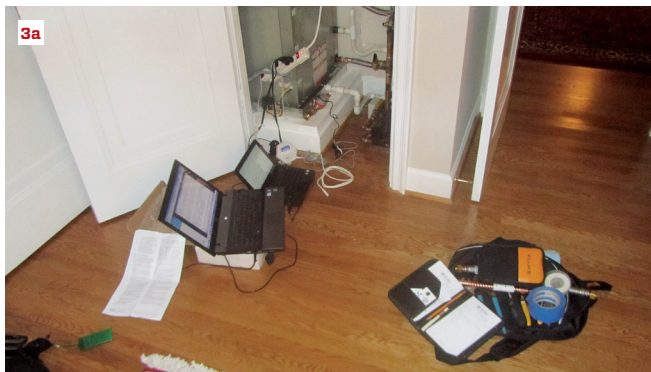
rooms started calling for heat, then would suddenly push several degrees hotter as the heat-cool-heat-cool cycle began.

When we showed the clients the graph demonstrating this pattern, they agreed to let us change the heat set-point in the other rooms during the afternoons so they wouldn't call for heat as often. This helped, but it didn't solve everything.

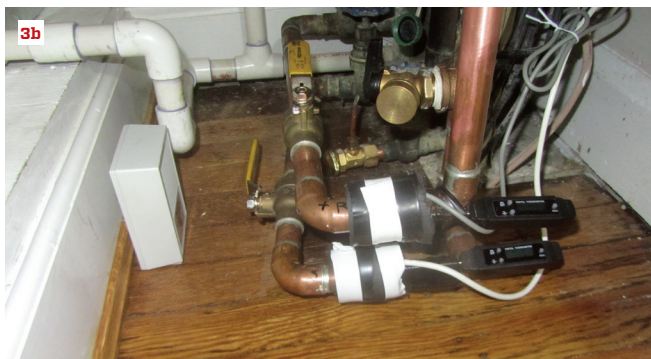
Follow-up recordings soon showed that on the hottest days, the kitchen still failed to cool. By watching kitchen humidity, we could see times when cooking without the

rangehood fan was the issue; but the problem happened even when humidity didn't spike from cooking. The rest of the house was staying cool, leaving inadequate air supply to the kitchen as the most likely explanation, so we added more ductwork.

In this particular house, the data recorders helped us find more than one problem and eliminate some theories about what was causing them. Certainly, the conversations with the homeowners and the HVAC contractors went much more smoothly with all the information we had.



3a. The HOBO ZW system setup is complex and requires an on-site computer, but the system can be monitored live over the Internet.



3b. To evaluate the performance of a condominium AC unit, the author secured temperature sensors to the inlet and outlet pipes, and a flow-rate meter in the HVAC system feed line.

CASE STUDY: CONDO AC FLOW RATE

In a high-end condo we renovated, the water-to-air HVAC unit had shut down on several hot afternoons, leaving our clients without AC. But two similar air handlers in the same apartment—and units in apartments above and below—didn't have issues.

After several troubleshooting visits, our HVAC techs were pretty sure the problem was inadequate water flow provided by the building's common system. Rather than point fingers at the building staff and have our clients experience another failure without knowing for certain what the issue was, we set up a monitoring system that would allow us to monitor the building water-flow rate and temperatures live over the Internet (**3a, 3b**). With this setup, we could definitively see what the issue was. The HOBO ZW software even allowed us to set "alarms." When the temperatures or flow went out of user-selected ranges, the system would email a warning.

Whether spurred on by pride in their work (they are good guys), or by the impending arrival of our flow-rate monitoring system, the building staff thoroughly checked and cleaned the pipes and valves running to our client's unit. Afterward, we had good flow and temperature almost all summer and never had a problem with the AC again.

This was not a case where the data helped us find a specific issue. But it is a case where everyone involved was glad to have conclusive evidence that all was well. Clients were happy (in fact, they seemed to enjoy checking the live flow rate and temperature "dashboard"), and if there had been an issue, we would have been able to find and fix it.

entire zone isn't holding temperature, indicating we might need more insulation or more air conditioning. Other times it's just the one room, in which case we might need more supply air or a high return in that room to fix the problem. In the case of the cold bedroom, the data allowed our HVAC guys to see that there could be a problem. We first tried adjusting the existing system, but in the end had to install a zone damper to finally resolve the issue.

It can be helpful to monitor humidity as well as temperature. We have found a couple of times that the humidity sharply rises in the problem time-frame. In our climate, that indicates either a lot of humid, outside air entering the space (kids leaving doors or windows open have been the "problem" a few times), or cooking or bathing without adequate ventilation. In these cases, we will usually have clear, hard data showing that the room can stay cool enough on hot days when the windows aren't opened (that is, when the humidity tracks normally), and, with the unbiased information in front of us,

we can have a productive, unemotional discussion with the homeowners.

In fact, this turns out to be the most useful role for the recorders. Like many contractors, I take a "just the facts" approach. However, not everyone on the project team may be on the same page. The people living in an uncomfortable space will typically have strong emotions about the problem, and in my experience, they often seize on a theory that has little basis in fact, due to their lack of experience. Similarly, a salesperson for a heating company, or a window distributor, or a talented architect, may have strongly held ideas about what a problem is, or at least may want to be quite certain what it is before they pay to remedy it. The information provided by data recorders can be invaluable in these situations because they provide excellent long-term data about the actual issues.

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