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Pitot-Tube Technology Helps Maintain Proper Airflow in Fitness Facility

Hot-wire anemometers succumbed to lint contamination

Airborne particulate not only degrades indoor-air quality, it can affect the performance of HVAC equipment. That was evident at the Rochester Institute of Technology (RIT) in Rochester, N.Y.

"The problem originated with our new 16,000-sq-ft, two-story fitness center, which is part of the much larger Gordon Field House," Richard Stein, HVAC-systems-support manager for RIT, said. "The entire complex is 160,000 sq ft, but the fitness center has its own heating and cooling system."

The fitness center has a dedicated 72-ton rooftop unit. This variable-air-volume system uses a control loop called "fan tracking," by which the control system uses feedback from two sensors that monitor airflow at the supply and return fans (approximately 25,000 cfm). The required volumetric offset between the two fan capacities is based on a number of factors, including carbon-dioxide concentrations, the number of exhaust fans in operation, and building pressure. Once the offset is determined, the control system uses feedback from the airflow-measurement sensors to modulate the return-air fan to meet the required set-point value. The supply fan has a variable-speed motor that allows the fan's speed to be modulated to maintain a constant static pressure in the supply ductwork. Likewise, the return fan has a variable-speed motor that the control system adjusts to work with the supply fan to maintain a slightly negative pressure in the fitness center. The negative pressure ensures that odors associated with the fitness center do not migrate to other parts of the building.

Gordon Field House at the Rochester Institute of Technology.

LINT AND STATIC ELECTRICITY

The airflow sensors in the fitness center were hot-wire anemometers, or thermal-dispersion devices. Such sensors use a very fine wire heated to a temperature above the ambient. Air flowing past the wire has a cooling effect. With the electrical resistance of most metals dependent on the temperature of the metal, a relationship between the resistance of the wire and flow velocity can be calculated.

"It's great when it works," Stein said. "But it gradually started to go out of sync. The return fan started to run faster than it should. Within three months, the fan was running constantly at 100-percent speed."

At its worst, the negative pressure was so strong that the structure drew in excessive amounts of unconditioned air. The hallways were wind tunnels. Doors were hard to open. Moist air from the swimming pool on the first floor was drawn into the fitness center on the second, where it condensed on windows.

"Fortunately, we were able to identify the cause as the anemometer airflow sensor for the return fan," Stein said. "The hot-wire anemometer was original equipment with the system and was just not intended for that kind of environment. A fitness center generates a lot of particulates, what with clothing, carpeting, and towels generating lint and the natural hair and other things given off from people exercising. Then, there is all the static electricity from the motors of the exercise equipment, which compounds the problem."

While air was filtered before reaching the supply fan, it was not before reaching the return fan. From the moment the return fan was turned on, lint collected on the hot wire of the sensor. As the lint built up, the sensor reported a lower-than-actual airflow rate, causing the return fan to run faster and extract more air than required.

A DIFFICULT MAINTENANCE JOB

"Every three months, we had to send someone in to clean lint off the hot wire," Stein said. "The space is very tight, and the technician had to lie on the grate to reach the sensor. It was a difficult task, and nobody liked doing it."

Stein wrote for the control unit a program that prevented the return fan from running faster than the supply fan, ensuring a slight negative pressure.

"It worked well as a temporary fix," Stein said. "But we still had to clean the anemometer's hot wire every three months, and we wanted to eliminate that difficult task."

PITOT-TUBE TECHNOLOGY

Stein spoke with Tim Blackburn of R.L. Kistler, the local HVAC distributor that supplied the rooftop unit.

"Rich came to us with the idea of putting a Paragon airflow-measurement device that uses Pitot-tube technology," Blackburn said. "We thought it was a possible solution since the Paragon device doesn't rely on a hot wire."

Named for its inventor, French engineer Henri Pitot, a basic Pitot tube points directly into an air stream. With air already in the tube, pressure can be measured as the moving air is brought to rest. Bernoulli's equation is used to determine the dynamic pressure of airflow. Accuracy typically is 2 percent.

"I had been a control contractor before I joined RIT and had used a lot of Paragon sensors with very good results," Stein said. "They seemed impervious to particulates in the air stream. So it was a logical choice when we had a particulate problem. I asked the folks at Kistler if they would be interested in doing a comparison between the two technologies, and they were. We installed the Paragon alongside the hot-wire anemometer and wired up a second input in the control logic. I can select either one to control the return fan and monitor the results."

Access to the airflow sensor was limited.

According to Stein: ***"The hot-wire anemometer performed exactly as it had before, collecting a coating of lint with our equipment, showing a linear degradation as the coating got thicker. After cleaning, the performance would bounce back up and then begin to degrade again. The Pitot-tube device didn't degrade at all, and it required no cleaning. It's still performing up to spec, and we haven't had to clean it. Naturally, we don't use the hot-wire anemometer anymore."***

The fitness center's airflow problem now is a thing of the past.

"We've used a lot of the Paragon devices around campus, and the only problem we ever had from them was when one of our technicians got a little happy with the grease and got some in the tube's inlet," Stein said. "Even then, the accuracy wasn't affected much."

A Pitot-tube sensor (foreground) and a thermal-dispersion device (background).

Information and photographs courtesy of Jack Sine.

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