Dedicated Outdoor Air Systems

Backup Condensation Control Via Portal Sensors

People continue to worry about condensation, particularly in buildings with operable windows. The concern is twofold—drips from the panels could damage items below, and condensation, even in small quantities, eventually may lead to microbial growth.

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Condensation is the No. 1 concern expressed when ceiling radiant cooling panels (CRCP) are considered for sensible cooling applications.

Prior ASHRAE publications[1,2] showed that condensation forms slowly and is easily controlled if adequate precautions are taken. The chief method to avoid condensation is to use a dedicated outdoor air system (DOAS) capable of removing the entire space latent load, which maintains a controlled dew-point temperature (DPT) environment for the panels to operate in.

Mumma

The automated control precautions tested and discussed in those publications included how to actively maintain the panel inlet water temperatures above the space DPT and how to detect condensation, then passively isolate the panels from the source of cooling. Nonetheless, people continue to worry about condensation, particularly in buildings with operable windows.

The concern is twofold—drips from the panels could damage items below, and condensation, even in small quantities, eventually may lead to microbial growth.

This column is an extension of the earlier work, but focuses on using window and door position sensors as a backup to active condensate controls. It also presents the author's experiences with fifth-year architecture students who work in the space and operate the windows.

Description

The condensation controls were applied in a second-floor 3,200 ft^2 (300 m^2) fifth-year architecture workspace (40 ft × 80 ft [12 m × 24 m] floor plan) that is occupied 24 hours a day, seven days a week and houses 40 students and five or so faculty consultants, along with their computers, overhead lights, lamps, refrigerators, coffee pots, etc.

It has one glazed southwest exterior exposure (384 ft^2 [36 m^2] single glazed movable sash, upper and lower sections), three interior walls adjacent to unconditioned spaces and two doors that open to an unconditioned space. The floor and ceiling are also adjacent to unconditioned spaces. The ceiling is 14 ft (4 m) high, with pendent illumination 9 ft (3 m) above the floor. There are eight evenly spaced two-way, 20 ft (6 m) throw, high-induction diffusers also 9 ft (3 m) above the floor that deliver 850 cfm (400 L/s) of 100% outdoor ventilation air. Finally there are eight free-hanging CRCPs that provide heat transfer on both top and bottom surfaces, each of which are 2 ft × 40 ft (0.6 × 12 m) (20% of the floor area) and evenly spaced 9 ft (3 m) above the floor.

The system schematic is presented in *Figure 1*. The main condensation control for the system consists of computing the space (or State 4) DPT from sensors T10 and H4 (dry bulb temperature [DBT] and percent relative humidity [%RH]). That DPT is used as the lower limit for the panel supply water temperature T3. Control valve V2 is modulated to meet the space DBT (T9), with the space DPT as the lower limit for T3. A more complete description of the systems controls may be found in *ASHRAE Transactions*.[3]

Adding Sash, Door Position Sensing

Anxiety about condensation sometimes causes use of CRCPs to be rejected in applications that have operable windows. Because sash position is an unknown for the system design and operation teams, the anxiety may be warranted. For example, in the fifth-year architecture space, the DPT reached a steady-state value near the outside DPT within 17 minutes of exterior doors and windows being opened simultaneously.[2] The control system worked as designed for that test, and condensation did not form.

Application Issues

However, because systems do not always work as designed, the current design has passive condensate sensor backup (COND in *Figure 1*). The sash/door position sensor backup (Win in *Figure 1*) is an alternative to the condensate sensor and can be used in lieu of or in addition to the condensate sensor.

Adding the sash/door position sensor was simple to implement and inexpensive. A magnetic switch was installed on each of the 12 windows and two doors. The normally closed switches were wired in series, producing one binary contact point for the automatic temperature control system. An open binary point indicates that a window or door has opened.

The binary point is used in the control logic, *Figure 2*, to take one of four actions (modes) if the doors or windows are left open:

Mode 1: Turn the entire mechanical system off—fans, pumps, and chiller.
Mode 2: Turn the chiller and pumps off.
Mode 3: Turn the chiller and pumps off if the outdoor air humidity ratio is less than that inside.
Mode 4: Completely ignore the sash position.

The control is set to allow the door or window to remain open for up to five minutes before any action is taken. To prevent short-cycling of the mechanical equipment, once action is taken the HVAC equipment will not start again for 15 minutes after all windows and doors have been closed.

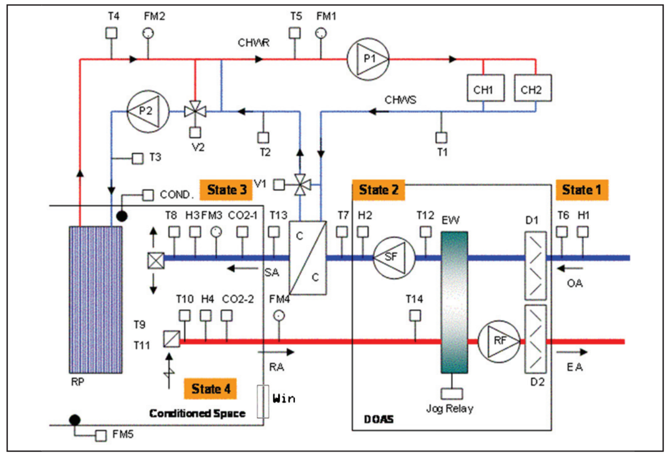

Figure 1: System schematic.

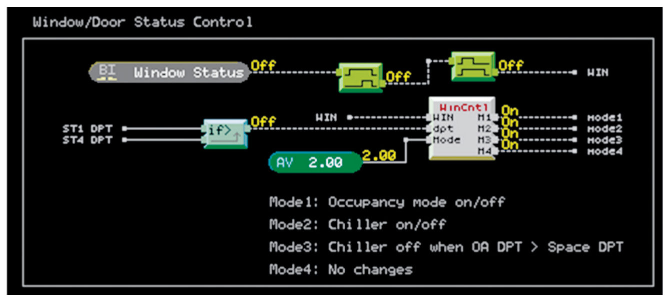

Figure 2: Sash position control function block.

Operating Experience

The sash position condensation prevention backup was added during the summer of 2004, and has been in service in both hot and humid and cold weather. As in the past, the students generally did not open the windows because they liked the indoor climate. However, even before the sash position retrofit the author noticed that on occasion the space DPT was hard to maintain and learned that students had opened a window(s) on a rainy day to listen to the rain. Because of the controls, there were no condensation problems. The incoming students for the 2004–2005 academic year working in the space also seemed to completely ignore the windows.

That changed during the long Labor Day weekend (Sept. 4–6, 2004) when the author placed the space in the unoccupied mode (cooling and ventilation fans off). The author didn't know the students had a project due on Sept. 7 and had to work in the space over the holiday. During this period, the outdoor air (OA) DBTs were in the 80s°F (~29°C) and the DPTs were in the low 60s°F (~17°C). The students completely opened all doors and windows. After this incident, even when the system was operating as desired, students often opened the windows.

The author met with the students to explain how the system operates and consequences of opening windows (the space heating up fast). The magnetic switches were set so that even a slightly open window is treated as open, causing the controls to shut down mechanical equipment.

Since it was difficult for the students to see if a window was fully closed, some method to determine if a window was opened or closed needed to be developed. One method considered was to install a light in the space that would indicate when a window was left open. The alternative the author chose was to give the students "look only" privileges on the Web-accessible controls.

After the system operation and control overview were given to the students, the control was placed in Mode 2—chiller off if windows left open. Because the ventilation air was still moving, students thought the system could not cool their workspace. Mode 2 did not make a significant impression on the students. When the control was changed to Mode 1, causing everything to shut down if a window or door was left open continually, the space heated to unbearable levels, and the students closed the windows and kept them closed.

Conclusion

Experience with the sash position sensors for backup control has lead the author to conclude that although condensation continues to be large deterrent for our industry, it never needs to be a problem with CRCPs, if the CRCPs are properly instrumented and controlled and operate in parallel with a well-designed DOAS.

References

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2. Mumma, S.A. 2003. "Chilled ceiling condensation control." *ASHRAE IAQ Applications* 4(4):22–23.
3. Mumma, S.A. and J. Jeong. 2005. "Direct digital temperature, humidity, and condensate control for a dedicated outdoor air-ceiling radiant cooling panel system." *ASHRAE Transactions* 111(1).

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