HEALTH FACILITIES MANAGEMENT

Airflow Controls Offered by Phoenix Controls

PANDEMIC READY

HVAC systems for worst-case scenarios

by Michael Soper

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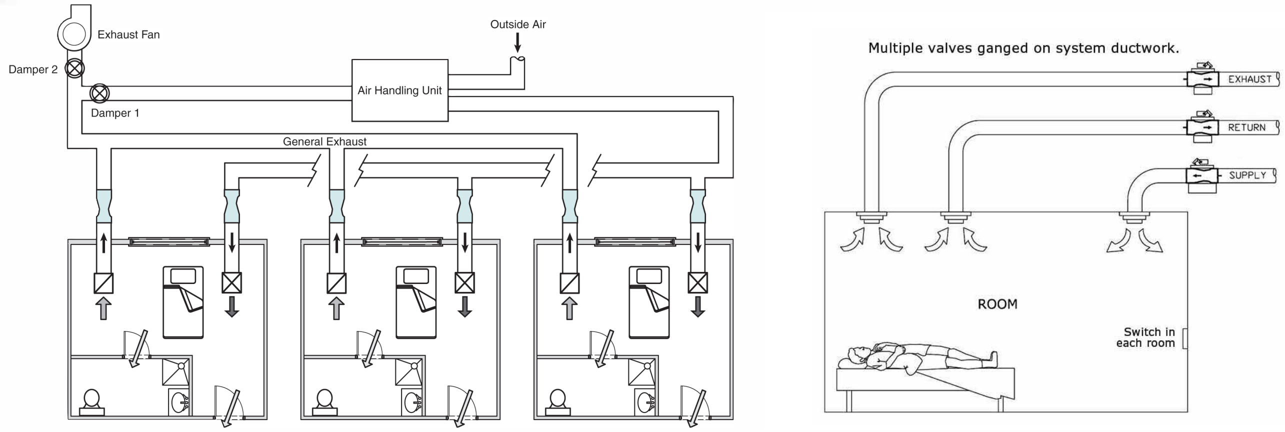
Tracking pairs of patient room venturi valves, which are used for room-level, pandemic-ready HVAC systems.

The term "infection control" is usually associated with the day-to-day practices of hand sanitation, disinfecting surfaces, wearing clean garments and monitoring the risk of cross-contamination between patients.

However, the term can also pertain to pandemic influenza. A pandemic can occur when a strain of the influenza virus mutates into a form not easily handled by the human immune system and is resistant to treatment with known medications. Most viruses of this type are highly contagious and will spread easily and rapidly throughout the global population. Influenza viruses have threatened the globe at least three times in known history and there is a widely held belief among scientists that a new pandemic is inevitable.

Considerable planning has been devoted to pandemic preparedness at the state and federal levels. However, facilities at the local level are thought to be unprepared to implement these plans. There would be inadequate staff, supplies would quickly run low and there would not be enough isolation rooms for contagious patients.

According to the Occupational Safety and Health Administration (OSHA), "the National Strategy for Pandemic Influenza calls for communities to antici-



LEFT Constant-volume valves with damper-controlled recirculation or exhaust. **RIGHT** Multiple VAV shutoff valves controlling recirculation or exhaust.

pate large-scale augmentation of existing health care facilities."

Furthermore, airborne precautions should include "placing patients in negative pressure rooms (airborne infection isolation rooms) or areas." The Centers for Disease Control and Prevention (CDC) advises "isolation of all persons with confirmed or probable pandemic influenza" in order to "delay the exponential growth in incident cases."

Pandemic-ready HVAC

A pandemic-ready HVAC system (PR-HVAC) can take several forms, depending on whether the desired control is zone-level or room-level.

Zone-level pressurization involves pressurizing floors above and below the pandemic floor, ensuring the pandemic floor is negative. Room-level pressurization enables normal patient rooms (which are usually either neutral or slightly positive to the corridor) to become negative when needed as an airborne infection isolation (AII) room. The engineer designing the system can use either approach or a combination to meet the unique needs and layout of the building.

While the *Guidelines for Design and Construction of Health Care Facilities* require isolation rooms to be fixed as either positive or negative airflow spaces, guidelines for patient rooms specify no requirement for pressurization. And there is nothing specific in current American Institute of Architects or American Society of Heating, Refrigerating and Air-Conditioning Engineers publications that prevent the use of patient rooms as AII rooms in an emergency. In fact, several U.S. hospitals have obtained approval from local planning and development authorities to implement PR-HVAC at the room level.

A closer look at the options available to HVAC design engineers includes the following:

Zone-level PR-HVAC. Using the term "zone" rather than "floor" to refer to HVAC control of an entire floor prevents confusion with floor-type ventilation systems that use under-floor distribution or displacement ventilation.

The basis for zone-level and room-level designs assume the use of venturi airflow valves because they perform better than air terminal units (ATUs) for maintaining the outlined pressure relationships under the varying conditions inherent in variable air volume (VAV) applications.

Venturi valves don't require flow sensors in the airstream to measure air flow rates. Flow sensors in ATUs are prone to clogging, especially in hospitals where bed linen particles get pulled into exhaust units. When flow sensors clog, flow rates are misreported to the building management system (BMS) and space pressurization can become compromised. Furthermore, venturi valves deliver reliable airflow cubic feet per minute (CFM) rates under changing conditions of duct static pressure, another common problem in HVAC systems. For these reasons, venturi airflow valves are recommended for conditions where space pressurization is critical, especially to contain dangerous airborne pathogens.

Zone-level negative pressurization can create what is effectively an isolation ward if adjacent zones are driven to positive pressure. Controlled doors buffer the elevator foyer and stairwells so the pressurized zone is isolated effectively.

The air handler can serve multiple zones or be dedicated to the pandemic zone. In either case, VAV airflow valves must be used in sufficient numbers to enable all spaces of the zone to simultaneously provide more exhaust airflow volume than supply, thereby creating the negative space. Similarly, zones above and below the pandemic zone must supply more airflow than exhaust so those spaces go positive. Positive adjacent zones ensure that no infiltration of airborne pathogens penetrates the space from the pandemic zone.

During normal operation, the entire PR-HVAC zone can function as regular patient rooms (neutral to the corridor), with the ventilation operating for comfort conditions and energy efficiency. In the event of a pandemic incident, personnel activate the PR-HVAC either through a key-switch, panic button or via a command initiated at the BMS front-end. This initiates the following sequence of operations:

1 / Control doors close in the pandemic zone and an audible alarm or announcement may sound.

2 / The pandemic zone increases total exhaust CFM volume to 10 percent more than supply CFM.

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3 / The pandemic zone control dampers change from air recirculation to 100 percent outside exhaust. This means that ductwork for both recirculation and outside exhaust is installed downstream of the damper. High-efficiency particulate air (HEPA) filtration on outside exhaust should be installed to protect maintenance and other service personnel from infectious agents at ventilation stack locations.

4 / Adjacent zones increase total supply CFM to 10 percent more than the exhaust.

Most suitable in retrofit situations, basic zone-level PR-HVAC can be implemented with minimal investment. Perimeter control doors may need to be installed. More ductwork and dampers would be needed to separate recirculation and outside exhaust. And additional BMS controllers may need to be purchased and control sequences may need to be developed to control dampers in multiple zones. But, essentially, an entire pandemic-ready isolation ward can be created with these modifications.

However, there are some disadvantages to zone-level PR-HVAC. One suspected case of pandemic influenza would mean the entire zone would need to convert procedurally and operationally to pandemic mode (assuming there are no isolation rooms available). Staff would need to limit access to the zone, activating their own preplanned pandemic response procedures and removing the zone from normal operational use for an undetermined period.

There may be additional expenses as well. Careful analysis should be performed regarding leakage in the building envelope and how this contributes to computing the volumetric offset required to create the negative pressure zone. Sealing fenestrations and measuring the results are expensive.

Room-level PR-HVAC. The alternative to zone-level PR-HVAC is room-level PR-HVAC. Room-level control provides more flexibility in the way the space can be used and creates more opportunities for energy savings during normal operations.

Because the ability to run multistate pressurization in individual rooms is best planned at the start of a project, room-level PR-HVAC is intended primarily for new construction. The primary benefit of room-level control is that each room can be converted to negative (or positive) pressure as required without disrupting services to other patients on the floor. Depending on the number and frequency of arriving patients during a surge, hospital staff can decide if and when to dedicate the entire zone to pandemic operations.

There are two room-level pandemic sequences to consider. One uses constant volume venturi valves with damper control and the other uses VAV venturi valves with shutoff capability and no dampers. As with zone-level control, the room's pandemic-mode sequence can be initiated by a key-switch, panic button or a command initiated at the BMS.

In a pandemic-mode sequence using constant volume valves, the venturi valves operate similar to an ATU but with the benefits described earlier. The diagram on the upper left-hand side of page 50 shows a pair of constant volume valves in each patient room. The valves are configured for fixed flow rates and paired so the installation delivers a predefined negative offset—in this case, 500 CFM supply and 450 CFM exhaust.

During normal operations, Damper 2 is closed to disable outside exhaust and Damper 1 is open to provide energy-efficient recirculation. HEPA filtration is not needed because recirculation will be disabled during pandemic-mode of operation. When pandemic-mode is required, Damper 1 closes to disable recirculation and Damper 2 opens for 100 percent outside exhaust. Because of the nature of venturi valve performance, the system will always deliver the predefined flow rates and 50 CFM negative offset, keeping the room negative.

In a pandemic-mode sequence using VAV shutoff valves, the venturi valves with shutoff capability perform two functions: They enable VAV but also control the state of recirculation or full exhaust without requiring dampers elsewhere in the ductwork.

The diagram on the upper right-hand side of page 50 shows three valves: a supply air valve, an exhaust air valve and a return air valve. The supply air valve and return air valve are called a "tracking pair." Thus, during normal VAV operations, the two valves track each other's offset, always maintaining 50 CFM negative offset through increases or decreases in airflow that may be used for occupied and unoccupied states. The exhaust valve is independently controlled by the BMS.

When pandemic mode is required, the following sequence is initiated:

1 / The return air valve moves from tracking the supply valve to shutoff position, disabling recirculation and seals the return air duct from contamination.

2 / The BMS system simultaneously starts the exhaust fan corresponding to the exhaust air valve and controls it to maintain adequate (0.3-inch water gauge or greater) duct static pressure.

3 / The supply air and exhaust air valves switch to tracking mode, maintaining the 50 CFM negative offset and enabling 100 percent outside exhaust.

4 / In neighboring rooms, the exhaust air valve remains shut off while supply air and return air valves track for normal energy-efficient operation.

With an integrated VAV and shutoff capability in the device, pandemic mode can also take place in the event of a power loss. Using spring-return actuators, the supply air and exhaust air valves can spring open to mechanical clamp (paired for 50 CFM negative offset) and the return air actuator can spring closed.

This type of VAV operation not only serves the hospital in the event of a pandemic, but also enables the most flexible use of the space as needs evolve. Since the rooms can be flipped to either negative or positive pressurization, the space can be used as acuity-adaptable rooms or for minor surgeries.

Other options. There are options for pandemic response other than these HVAC designs. For instance, with the right procedures in place and periodic mock-pandemic exercises, hospitals can make plans to respond to an outbreak using makeshift facilities for triage. These can be erected rapidly using tents with portable ventilation systems, rapid-deployment containment spaces for isolation wards and various other systems that utilize inexpensive and

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easy-to-store materials.

These methods may result in effective handling of patients if executed well, but there is a high risk of procedural error and equipment failure.

Ensuring performance

PR-HVAC is a key component of modern hospital design. Room-level PR-HVAC gives the facility the most flexibility to use the space for a variety of services, energy efficiency and pandemic-preparedness. Zone-level PR-HVAC is a sensible approach for retrofit application. And product choice for reliable HVAC performance is critical to ensure the intended pressurizations.

Regardless of the design approach, it is essential to ensure the PR-HVAC system functions as designed, so the facility is truly ready to contain a dangerous virus. This means the systems should be switched to pandemic mode annually for several days and monitored at the BMS for proper pressurization.

During operation it is important to verify at least 0.01-inch water gauge of differential pressure between the pandemic areas and reference spaces. This can be measured using an airflow multimeter. A more exhaustive verification can be performed by augmenting the practice run with a particle counter to assess the efficacy of directional airflow and HEPA filters.

The threat of a pandemic is real. Health facilities should take steps during renovation and new construction to have systems ready to respond. ■

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NORTHWEST COMMUNITY HOSPITAL PLANS PANDEMIC-READY PATIENT ROOMS

Northwest Community Hospital, Arlington Heights, Ill., is building a new patient care addition that will offer the community state-of-the-art care in a modern structure designed for family-centered healing. The new building is designed to harvest natural light and provide views of nature to aid in the healing process. Designed by OWP/P of Chicago, the project consists of 332,573 square feet of new and remodeled space, including a new entry and lobby, a 24-bed critical care unit, labor and delivery rooms, post-surgical care rooms and a new parking garage. Slated for completion in 2010, the nine-story tower will increase the hospital's staffed bed count from 410 to 488, and include patient rooms designed to accommodate a surge of potentially infectious patients.

RENDERING COURTESY NORTHWEST COMMUNITY HOSPITAL, ARLINGTON HEIGHTS, ILL.

The mechanical systems on the fifth and ninth floors are designed to permit the hospital to respond to a pandemic incident, should it ever occur in the community. Should pandemic influenza strike, the patient rooms on these floors can be used to isolate patients with the flu contagion, serving both the well-being of the patient and safety of staff and the general public.

These pandemic-ready patient rooms become isolation rooms on demand using a building management system (BMS) command sequence that can be initiated by the facility engineer. The BMS command causes the HVAC control system to change the balance of supply and exhaust air volumes to ensure that the direction of airflow is from clean to unclean areas in each patient room. Two cubic feet per minute (CFM) quantities and control sequences are specified: normal and emergency. Normal CFM quantities provide equal air volumes between supply and exhaust as well as central air recirculation to conserve energy. This enables neutral patient room-to-corridor pressurization during normal day-to-day operations. When necessary, emergency CFM quantities provide more air volume to exhaust than supply, and full exhaust venting to the outdoors. This converts a normal patient room to a negative pressure bed or airborne infection isolation room.

Using the right combination of variable air volume devices and controls, OWP/P was able to design a patient space that provided an efficient and comfortable environment under normal operations, but that could respond immediately to the need for an isolation room in a public emergency.

Founded in 1985, **Phoenix Controls Corporation** is a recognized leader in the design and manufacture of precision airflow control systems for use in critical room environments. Theris® is Phoenix Controls' family of variable air volume (VAV) and constant volume (CV) airflow control systems designed for healthcare facilities. Using Theris, health care facility owners can reduce maintenance costs, reduce the spread of airborne pathogens and conserve more energy. **Learn more about how Theris can provide a pandemic-ready HVAC system at healthcare.phoenixcontrols.com.**