ASHE Monograph

Operating Room HVAC Setback Strategies

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Chicago

The American Society for Healthcare Engineering (ASHE)
of the American Hospital Association
155 North Wacker Drive, Suite 400
Chicago, IL 60606
312-422-3800

ashe@aha.org

www.ashe.org

Acknowledgments

ASHE gratefully acknowledges the expertise and experience shared by the following contributors:

Steve M. Burch, PE, LEED® AP, Principal, Mazzetti Nash Lipsey Burch

Bob Gulick, PE, LEED AP, Principal, Mazzetti Nash Lipsey Burch

Jon Inman, PE, LEED AP, Principal, Mazzetti Nash Lipsey Burch

Richard Moeller, PE, SASHE, LEED AP, HFDP, Principal, CDi Engineers

Michael Sheerin, PE, LEED AP, BD+C, Principal, Director of Healthcare Engineering, TLC Engineering for Architecture

Ed Tinsley, PE, CEM, LEED AP, HFDP, Executive Managing Principal, TME, Inc.

Contributing Author

Christy Love, LEED AP, BD+C, Mechanical Designer, Mazzetti Nash Lipsey Burch

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Operating Room HVAC Setback Strategies

This paper identifies operating room (OR) heating, ventilation, and air conditioning (HVAC) setback strategies, summarizing the opportunities and main considerations for using them and describing options for implementing them.

The scope of the paper is not intended to provide professional advice or detailed design guidance but rather to introduce the setback concept and highlight some issues to help health care organizations decide if the strategy is right for them. Facility engineers and operators are encouraged to enlist the assistance of an HVAC or mechanical design professional when they are ready to consider implementation at their facilities.

1 What is a setback strategy and why use one?

Operating room HVAC setback (also referred to as "night setback" or "unoccupied setback") is an energy-saving strategy that reduces the amount of air supplied to an operating room when the room is not in use. It may also allow temperature or humidity settings or both to drift during times when the room is not in use.

Depending on the type of facility and the pattern of use for its surgery facilities, an operating room may be unoccupied 40 percent or more of the time. Considering the high air change rate, high percentage of outside air, and often significant cooling and humidity requirements at full occupancy as well as the high reheating load during unoccupied periods, a hospital or ambulatory surgery center can realize significant energy savings by adopting an HVAC setback strategy. Savings will be greater for facilities located in more extreme climates (with correspondingly higher heating or cooling and reheating loads), but are appreciable regardless of the climate. Particularly when 100 percent outside air is used, the return on investment can be realized within as little as a few years.

Operating room setback during unoccupied periods is neither a new nor an unproven approach. For example, OR setback has become standard practice in Washington State since it implemented its own health care design standard in 1986. However, before moving forward with the technique, facility staff should understand specific factors that influence how the approach is implemented in a particular situation, along with the range of potential solutions.

2 Are our operating rooms good candidates for OR setback?

All operating rooms are potential candidates for a setback strategy. As a first step in considering adoption of a setback strategy, the facility and design team completes a basic assessment to weigh the benefits and costs of implementation and to determine if the expected rate of return meets the facility's requirements or expectations. A basic assessment can also determine the method of setback control that offers the best solution for a particular facility. Factors to consider include those described below.

2.1 Staff Usage

Develop a profile of actual or expected OR occupancy to help the HVAC or mechanical designer estimate order-of-magnitude savings and determine the optimal control strategy. A basic question to ask would be whether the facility needs to have one or more ORs ready for use at all times, as in a trauma facility, or whether its OR schedules are more predictable.

2.2 Existing Conditions

If a setback strategy is being considered for a retrofit project, how does the existing HVAC system condition and control airflow to the ORs? How many ORs are served by each air-handling unit (AHU)? Are there terminal boxes for each OR? The configuration of the existing HVAC system will inform both the scope of the upgrade and the decision on which control strategy is optimal.

2.3 Cost

A setback strategy planned for a new health care facility can be incorporated with little or no additional upfront cost. In a retrofit of an existing health care facility, however, upfront costs must be weighed against the expected energy savings from implementing an OR setback strategy. Since most OR setback setups will require at least periodic maintenance, maintenance costs also need to be considered. The total cost of implementing a setback strategy will depend on the specifics of the strategy selected. Generally, a finer level of control means a more complex system and thus a higher cost. The trade-offs between control and cost are discussed in greater detail in the next section.

ASHRAE 170 Operating Room Ventilation Requirements

The Facility Guidelines Institute's *Guidelines for Design and Construction of Health Care Facilities* provides comprehensive guidance for hospital design and is the referenced health care facility standard for many state and federal codes. The 2010 edition of the FGI *Guidelines* incorporates ANSI/ASHRAE/ASHE Standard 170-2008: *Ventilation of Health Care Facilities*. Section 7.4.1 of this standard requires that:

> Operating rooms shall be maintained at a positive pressure with respect to all adjoining spaces at all times. A pressure differential shall be maintained at a value of at least +0.01 in. wc (2.5 Pa).

This requirement applies during both occupied and unoccupied modes. However, per Section 7.1 of ASHRAE 170:

> For spaces that require a positive or negative pressure relationship, the number of air changes can be reduced when the space is unoccupied, provided that the required pressure relationship to adjoining spaces is maintained while the space is unoccupied and that the minimum number of air changes indicated is reestablished anytime the space becomes occupied. Air change rates in excess of the minimum values are expected in some cases in order to maintain room temperature and humidity conditions based upon the space cooling or heating load.

3 What are the controlling factors for OR HVAC setback strategies?

When facility staff elect to move forward with an HVAC setback strategy for their operating rooms, it is helpful to understand the factors that control operation of the ORs and the key considerations that will determine how the setback strategy is implemented. These controlling factors and setback considerations are briefly described in this section.

3.1 Air Change Rates (ACH)

State and federal codes govern the minimum total and outdoor air change rates for ORs. For instance, ANSI/ASHRAE/ASHE Standard 170-2008: *Ventilation of Health Care Facilities* requires a minimum of 20 ACH total and 4 ACH of outdoor air when the room is in use. However, 20 to 25 total ACH are commonly needed to maintain temperature, ensure particulate removal, and overcome equipment loads, allowing the facility to easily meet or exceed the code requirements for ventilation in occupied mode. In unoccupied mode, the requirements to maintain positive pressure and humidity below 60 percent,

1. Although ANSI/ASHRAE/ASHE Standard 170-2008 does not prescribe minimum ACH for unoccupied mode, some codes do (e.g., the California Mechanical Code allows a minimum of 6 total ACH).

along with user needs (e.g., for fast start-up of an unoccupied OR), govern the practicable minimum ACH.[1] (See the sidebar to read relevant language from ASHRAE 170.)

For mixed air systems, it is also important to recognize that as the setback strategy varies, the supply air rate and the quantity of outside air can also vary. In addition, exhaust air quantities must be coordinated to maintain appropriate building pressurization.

3.2 Pressure Relationships

All health care mechanical and ventilation codes require that ORs maintain a positive air pressure relative to surrounding spaces, whether the OR is in occupied or unoccupied mode. It is this requirement that makes OR setback strategies more complicated than setback strategies for non-critical spaces. An OR must retain a positive pressure relative to surrounding spaces at all times, and the room leakage rate determines the CFM (cubic foot/minute) differential between supply and return air that is needed to maintain that pressure.

One AHU often serves multiple ORs due to the high cost of providing one unit for each OR. Generally, when this is the case, it is essential to understand the pressure relationships between all the spaces the AHU serves as well as the system implications of reducing the airflow to one or more of those spaces.

The accompanying table summarizes three strategies suitable for controlling pressure in an OR. These are offered as examples that have proven successful for designers and users, but other methods may also be suitable. Note that the table lists design considerations for each strategy that are not discussed in this paper. This information would be thoroughly reviewed by a design professional familiar with a design or renovation project to help assess the appropriateness of a strategy.

3.3 Temperature Requirements

The temperature requirements of particular ORs may influence the setback strategy selected. Some ORs require temperatures as cold as 62°F (17°C) and—depending on the local climate and the speed with which surgeons want their OR to reach occupied mode—maintaining temperature at or close to the occupied temperature during setback mode may be preferred over allowing the temperature to fluctuate. Designers need to remember that

Sample Pressure Control Strategies

Control Strategy	Complexity	Level of Control	Cost	Design Considerations
A two-position (min/max) variable air volume (VAV) box is installed on the supply air source. Supply airflow is controlled to setpoint. Shut-off dampers are installed in the return ductwork equal to the amount of the setback volume. The VAV box and dampers are balanced to the maximum and minimum volumes for occupied and unoccupied modes. When the VAV box switches to the unoccupied mode, the return dampers (controlling the setback volume) close.	Low	Low	Low to Moderate	► Provides volumetric control to maintain pressure differential. ► VAV box and return damper require periodic recalibration. ► Cost for a system with one AHU per OR is low. If an AHU is serving multiple ORs, balancing can be challenging. One option would be to put the return damper(s) that will close during unoccupied mode on a dedicated exhaust fan (one per OR) so the exhaust shuts off during unoccupied mode and the return air system remains at constant volume. ► A variable frequency drive (VFD) is needed on the air-handling unit.
Pressure-independent valves are placed on the supply and return ductwork (and potentially on ductwork serving surrounding spaces). The supply airflow is controlled to setpoint. The valves, calibrated to the maximum and minimum volumes for occupied and unoccupied modes, maintain the desired offset.	Moderate	Moderate	Moderate	► Provides volumetric control (with “tracking return”) to maintain pressure differential. ► The valves can be calibrated at the factory and require minimal ongoing maintenance or recalibration. ► Requires two valves (on supply and return) or more (possibly in ducts outside the OR). All of these valves must accurately relate to one another. ► Needs VFD on the air-handling unit.
A modulating control damper is installed in the return duct and controlled by a room pressure sensor. The damper modulates to maintain a positive relative room pressure during both occupied and unoccupied modes. A standard terminal box controls the supply airflow to setpoint for each sequence.	Moderate	High	Moderate	► Controls pressure directly. ► Allows the room to automatically respond to pressure changes outside the room by modulating the amount of return air. ► The pressure transmitter must be tuned and calibrated regularly. ► Needs VFD on the air-handling unit.

less energy is needed to maintain room temperature in ORs during unoccupied periods because equipment loads are low to non-existent when the room is not in use and, because ORs are typically located in the building core, they are not affected by temperature gains and losses in the building envelope. On the other hand, the time it takes ORs in unoccupied mode to reach occupied mode temperature can take longer if the unoccupied room temperature is allowed to migrate too far from the desired user setpoint.

3.4 Humidity

The humidity control requirements of ORs have considerations similar to those for temperature requirements. Unoccupied mode requires some level of humidity control to mitigate environmental conditions that could promote condensation or other moisture issues. According to Addendum d to ASHRAE Standard 170-2008, relative humidity can range between 20 and 60 percent whether occupied or unoccupied.[2]

2. Although ASHRAE 170 reflects current best practice, some codes still reference NFPA 99, which sets the minimum humidity at 35 percent.

3.5 Particulate control

OR setback strategies typically do not monitor and respond to particulate levels. Unless there is a contaminating event, it is assumed the normal HVAC filtration, coupled with positive pressure relative to surrounding areas, will maintain directional airflow to minimize contamination from surrounding spaces.

3.6 User Needs and Preferences for System Interface Control

The system interface gives staff control of the HVAC system settings. Interface methods chosen must reflect the needs, preferences, and perceptions of the system's users. Some users prefer a simple system interface such as a series of pushbuttons, while others are more comfortable interacting with the system directly, perhaps using a control panel that shows the temperature, pressure, and humidity settings. To respond to these differences, the control options installed may vary between ORs in the same facility. For instance, one OR may be kept in "ready" mode (i.e., in occupied mode), even though there is no code requirement to do so. It is important to work with both clinical and facility staff to establish an interface control solution that best achieves the joint goals of meeting user needs and saving energy. Described below are a few common interface options.

3.6.1 Time Schedule Program

A time schedule program can be an effective means of controlling the HVAC settings in ORs that are used regularly throughout a typical day or week. The schedule shows when each OR is scheduled for occupied or unoccupied mode. A time schedule program is easy to understand and modify and does not require interaction from users as it is usually part of the building automation system. Time schedule controls are well-suited for use in ambulatory surgery centers, where surgical teams keep finite hours and no emergency cases are anticipated.

3.6.2 Occupancy Sensors

Occupancy sensors (which can combine audio, infrared, and motion detection) are used to switch an OR between unoccupied and occupied modes. These sensors provide an automatic mode of control that does not require user interaction. The sensor controls often embed a delay in the change to unoccupied mode so the system ramps down slowly enough to maintain positive pressure in the HVAC system. The sensors may also embed a delay in the switchover from unoccupied to occupied mode to correct for brief entries into the room (e.g., users borrowing equipment or passing through).

3.6.4 Manual Switchover

An OR can be fitted with controls (typically using an OR interface panel) that are manually activated when the room is to be occupied. The time it takes the HVAC system to reach occupied mode settings is typically much shorter than the time it takes the surgery team to prepare for surgery. When this control method is chosen, though, staff must be trained to press the button that reactivates the HVAC system when it anticipates the OR will be needed.

3.6.5 Combined Control Methods

Any of the control methods described above can be combined to provide flexibility as operational patterns change over time.

For example, one comprehensive approach may be to operate on a time schedule, but to install occupancy sensors and a manual override button for use during unscheduled events. When the time schedule is in unoccupied mode (e.g., overnight) but the occupancy sensors indicate the room is occupied, the system will switch to occupied mode after a defined delay (e.g., 30 minutes). This will account for temporary, non-surgery-related occupancies such as cleaning. The override button allows the surgery team to override the delay immediately if the room is needed for an unscheduled surgery. After a manual switchover, the OR can be set to remain in occupied mode until the next unoccupied cycle in the time schedule (usually the next day).

Any of the user interface methods can also be paired with visible indicators such as a green light in the OR when the OR is in full occupied mode and a red light when it is in unoccupied mode.

4 Summary

Operating room setback is a proven energy-saving strategy for hospitals and ambulatory surgery centers in all climates. However, because of the unique constraints governing the design and operation of ORs, several factors must be considered when designing a solution for a particular facility. A successful solution must take into account the local climate, facility type, and user needs and adhere to applicable code requirements.

Each of the many potential setback solutions has corresponding trade-offs between the level of control, complexity, and cost of the strategy chosen. This paper outlines the possibilities to consider and provides questions to ask in determining which approach to use for a particular situation. An experienced design professional with detailed knowledge of the facility and its users' needs can assist facility staff in identifying the optimal solution.

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