



**Surgery Suite HVAC Systems: Current Performance Demands with Existing Systems**

by R. Clay Seckman, P.E.

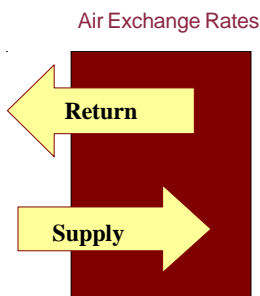
**Surgery Suite HVAC Systems**

Facility managers wrestle every day with systems and components that were designed for one use, but are now expected to serve different needs. Systems often become inadequate for these changing needs long before they reach the end of their useful life.

Changes in the healthcare industry with respect to delivery of care, technology, reimbursement, staffing and a host of other issues are driving an accelerated increase in facility performance expectations. A look at surgery suite heating, ventilation and air conditioning (HVAC) systems will reveal one such challenge facing facility managers today. This article is intended to review several traditional design concepts for surgery HVAC systems, how changes in performance expectations have challenged those concepts and options with which to move forward.

**Standard HVAC Design Concepts**

There are four basic HVAC aspects to design concepts that include air change rate, air flow pattern, filtration and room environmental conditions. These four aspects will determine the design and performance of a majority of HVAC systems.

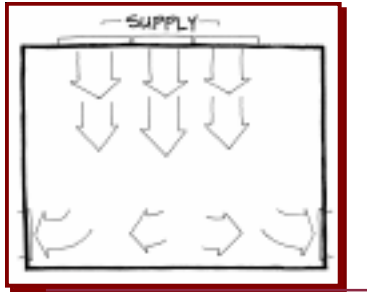


Air Changes per Hour (ACH) =  $\frac{CFM \times 60}{\text{Room Volume (ft}^3\text{)}}$

1. *Air Change Rate:* This standard for surgery rooms (defined in terms of air changes per hour [ACH]) has evolved through the days of flammable anesthetics, the energy crisis and now through issues such as indoor air quality and infection control. Code requirements have varied from 15 ACH (using 100% outside air in the days of ether use) to 25 ACH. The current code requirement is 15 ACH by The 2001 AIA Guidelines (some requirements may vary by state), although that figure will often be exceeded by room load and performance demands. A typical air change rate design will maintain the general operating room at 25 ACH and the orthopedic or cardiovascular operating room (CVOR) at 40 ACH.

# Surgery Suite HVAC Systems

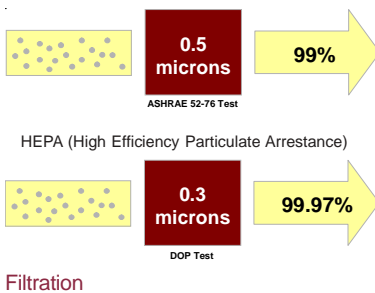
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Unidirectional (Laminar) Airflow Pattern

2. *Air Flow Pattern:* In the early days of conditioning surgical spaces, directional air flow was not a major consideration, as the use of sidewall supply and return grilles was often dictated by low floor-to-floor heights. The concept of a “laminar air flow” pattern has evolved as the awareness of particulate generation and protection of the wound site has grown. Current standard HVAC design shows overhead supply devices with low velocity, non-aspirating (no mixing of room air with supply air) grilles concentrated over the operating table. Return or exhaust air is taken in multiple locations at the floor level to create a “once-through” pattern.

3. *Filtration:* Filtration has also evolved from minimal importance during the 100% outside air days to current concerns with recirculating systems. The typical filtration target is a bacteria host, usually 0.5 microns or larger, with studies showing most bacteria ride on such sized particles. Standard high efficiency filters (bag or pleated) rated to be 95% efficient by the ASHRAE 52-76 test will remove 99% of particles 0.5 microns and larger. HEPA filters are rated to be 99.97% efficient on particles 0.3 microns and larger. HEPA filters provide a dramatic increase in performance but are more expensive to install and operate. Typical filter arrangement includes low efficiency filters upstream of coils and fans, high efficiency filters downstream of fans and HEPA filters, if used, in the terminal position either at the air



handler or at the supply diffusers.

4. *Room and System Conditions:* Of these four aspects, room and system operating conditions have seen the greatest change in expectations. Very few of these changes have been driven from a regulatory (code) perspective, but due to the combined evolution of user demands, patient needs and medical procedures, the definition of a true “standard” is very broad. The common denominator, however, is the push for colder rooms and increased ability to change room temperatures quickly.

The development of specified room temperature requirements with concurrent relative humidity limits was intended to limit the danger of static electricity sparks with ether use, and to limit bacteria growth in too-dry or too-moist conditions. The current code-specified ranges of 68-73 degrees F. dry bulb with concurrent relative humidity of 30-60% can typically be achieved using conventional HVAC equipment producing supply air temperatures in the 50 to 51 degree F. range. As we’ll discuss next, these conditions rarely meet current expectations.

## Current HVAC Performance Demands and Expectations

HVAC system performance historically has been measured against an ever-evolving standard, especially in the surgical environment. With increased staff protective gowning and masking, longer procedures for CVOR and orthopedics, effects of room temperature on anesthetized patients, infection control and other issues, there has been two basic fundamental shifts in surgery room expectations.

# Current Performance Demands with Existing Systems

1. *Basic room temperature.* 68 to 70 degree F. expectations have given way to rooms at 55 to 65 degrees F.
2. *Rate of temperature change.* For cardiovascular and certain pediatric cases, the temperature of the room is expected to be relatively warm at the outset of a procedure, dropped quickly once the patient is anesthetized and returned to a warm state upon completion. As rooms are also used in multi-purpose modes, back-to-back procedures are requiring different room temperatures, and systems must be capable of responding quickly.

## Impact to Existing HVAC Conditions

These increased demands primarily impact two major aspects of HVAC system design: 1) the air change rate and 2) the system operating conditions. A widespread misconception is that lower room conditions can be achieved simply by increasing the air change rate in the room, when in reality the actual conditions of the incoming air stream must be lowered for both the temperature and humidity.

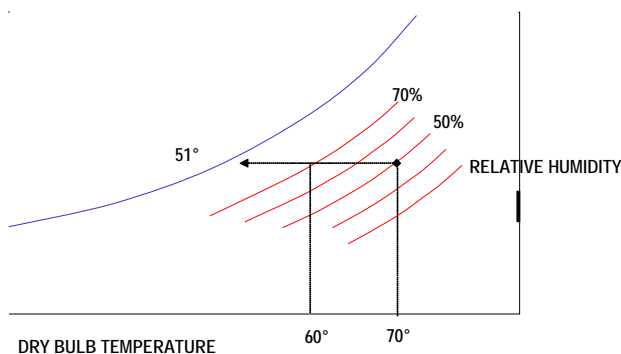
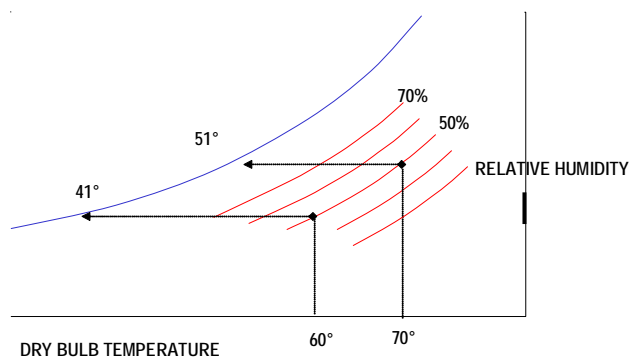


Figure 1 above represents a simplified psychrometric chart, and demonstrates the results of conditioning a

room to a colder dry bulb temperature than for which the system was designed. In this example, a space designed for 70 degrees F. and 50% relative humidity requires air coming off the cooling coil at 51 degrees F. If an attempt is made to cool the space to 60 degrees F. (by increasing the air flow rate but not changing the supply air conditions), the resulting relative humidity will be approximately 70% and outside the required range.

The result of this is the basic inability to simply cool off surgery spaces by operating the system at a colder condition. Rather, fundamental design parameters need to be modified. The psychrometric chart in Figure 2 shown below demonstrates that in order to deliver 50% relative humidity at the 60 degree F. room temperature, supply air must be produced at approximately 41 degrees F. This is largely unachievable with conventional chilled water or direct expansion equipment.



Rate-of-change demands in room temperature levels primarily impact the air change rate and, to a lesser degree, the supply air stream temperature. This becomes a raw capacity issue, as the load to cool the temperature of a room from 75 degrees F. down to 60 degrees F. is many times greater than required to simply maintain it at 60 degrees F. Adequate temperature change performance will usually require 30 to 40 ACH levels or higher.

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## Existing HVAC System Modifications

HVAC system upgrades to meet higher performance expectations will generally fall into two categories, lowering the existing supply air temperature and/or increasing the air change rate. Lower supply temperatures can be achieved through the addition of supplemental cooling coils, such as glycol, brine or direct expansion to allow them to operate below freezing conditions. These additions involve challenges such as available space for added coils, increased static pressure loss, refrigeration source and control sequencing.

Modifications to increase air change rates can be more challenging and usually require increased ductwork sizes, additional diffusers in the surgery ceiling, air handler replacement and other major system modifications.

## Considerations for New Construction or Renovation

The facility manager embarking on a new or renovated surgery suite should consider these issues related to the HVAC system design.

1. Define and document the desired room conditions and performance requirements early in the design phase.
2. Require the design engineer to demonstrate the ability of the system to achieve these levels.
3. Evaluate specific needs for supplemental refrigeration, possible low temperature applications and redundancy purposes.
4. Consider the use of a “dual-path” system approach, which reduces energy usage by treating outside air separately from return air.
5. Evaluate the impact of design on floor-to-floor clearance, ceiling coordination and noise issues.
6. Evaluate redundancy and backup provisions.
7. Evaluate moisture control and condensation issues for cold surgery areas with exterior exposures.
8. Discuss every aspect and expectation of the system with the user, designer and facility manager prior to initiating the design phase.



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