

Current Trends for Health-Care Ventilation

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Health-care design evolves constantly, reflecting improvements and advancements in surgical techniques, equipment (such as MRIs and robotic surgical equipment), clinical practices, hospital design trends, energy efficiency, sustainable design, and other factors. Ventilation for health-care facilities must change to be aligned with the changing needs of health-care facilities design, patients, surgeons, clinical staff, and visitors.

ASHRAE/ASHE Standard 170, *Ventilation of Health Care Facilities*, was originally published in 2008¹ and was recently updated in January 2014.² The standard was written by ASHRAE and the American Society for Healthcare Engineering (ASHE).

The standard has been under continuous maintenance since 2008. Consequently, all of the changes within the 2013 edition have been previously published as addenda. This has been an ongoing process for the past five years.

This article recaps some of the more notable changes to the standard.

Humidity

The lower limit of the design relative humidity for some room types is now 20% RH. The rooms are listed in *Table 1* (Table 7.1 of the standard).

The rooms with the 20% minimum relative humidity requirement are considered “short-term stay” rooms. It is self-evident that this is where the patient will not stay for long periods of time, and the exposure to relative humidities as low as 20% will have negligible effect on the patient’s care and well-being. No adverse clinical health effects have been reported (to the committee).

This change became effective in June 2010 and has been well-accepted by designers and building owners. In colder climates, this change reduced adverse effects associated with unintended condensation and allowed for reduced energy use. For many climates, it allows for reduced equipment cost because less humidification may be provided. For some climates, it may be possible to avoid humidification equipment. The minimization or reduction of humidification equipment is considered beneficial because humidification equipment often becomes a maintenance headache and sometimes a source of amplification of fungi and their spores.

Operating Room Nomenclature

Operating rooms had previously been categorized as Class A, B and C since the initial publication of Standard 170 in 2008. This approach was devised to align with guidelines by the American College of Surgeons.³

Preceding anticipated changes in the 2014 edition of the FGI Guidelines, the 2013 edition of Standard 170 has changed the terminology so that there are no longer three classifications of operating rooms. There are now only two classifications: procedure room and operating

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TABLE 1 Rooms with 20% RH for lower range of humidity (extracted from Table 7.1 Design Parameters).²

| FUNCTION OF SPACE | PRESSURE RELATIONSHIP TO ADJACENT AREAS | MINIMUM OUTDOOR ACH | MINIMUM TOTAL ACH | ALL ROOM AIR EXHAUSTED DIRECTLY TO OUTDOORS | AIR RECIRCULATED BY MEANS OF ROOM UNITS | RH (%) | DESIGN TEMPERATURE (°F) |
|---|---|---------------------|-------------------|---|---|--------|-------------------------|
| SURGERY AND CRITICAL CARE | | | | | | | |
| OPERATING ROOM (CLASS B AND C) | Positive | 4 | 20 | N/R | No | 20-60 | 68-75 |
| OPERATING/SURGICAL CYSTOSCOPIC ROOMS | Positive | 4 | 20 | N/R | No | 20-60 | 68-75 |
| DELIVERY ROOM (CAESAREAN) | Positive | 4 | 20 | N/R | No | 20-60 | 68-75 |
| TREATMENT ROOM | N/R | 2 | 6 | N/R | N/R | 20-60 | 70-75 |
| TRAUMA ROOM (CRISIS OR SHOCK) | Positive | 3 | 15 | N/R | No | 20-60 | 70-75 |
| LASER EYE ROOM | Positive | 3 | 15 | N/R | No | 20-60 | 70-75 |
| CLASS A OPERATING/PROCEDURE ROOM | Positive | 3 | 15 | N/R | No | 20-60 | 70-75 |
| RECOVERY ROOM | N/R | 2 | 6 | N/R | No | 20-60 | 70-75 |
| DIAGNOSTIC AND TREATMENT | | | | | | | |
| GASTROINTESTINAL ENDOSCOPY PROCEDURE ROOM | N/R | 2 | 6 | N/R | No | 20-60 | 68-73 |

room. The new classifications compare to the Class A, B, and C designations are as follows:

Procedure Room (formerly Class A surgery) provides minor surgical procedures performed under topical, local, or regional anesthesia without preoperative sedation. Excluded are intravenous, spinal, and epidural procedures, which are Class B or C surgeries.

Operating Room (formerly Class B surgery) provides minor or major surgical procedures performed in conjunction with oral, parenteral, or intravenous sedation or performed with the patient under analgesic or dissociative drugs.

Operating Room (formerly Class C surgery) provides major surgical procedures that require general or regional block anesthesia and/or support of vital bodily functions.

This change reflects how procedure rooms and operating rooms have been incorporated in the programming of health-care facility designs. Few, if any, programs/designs discriminated between Class B and Class C operating rooms. And similarly, most programs/designs addressed procedure rooms, rather than Class A operating rooms. The requirements for operating rooms and procedure rooms remain unchanged.

Ducted Returns

For inpatient care in locations such as hospitals, ducted returns systems are required for patient care

rooms using plenum return are not permitted. This is aligned with requirements in the FGI Guidelines⁴ and is accepted as a minimum requirement. The ducted return systems provide control of the air returned to the air-handling unit, allowing positive control of the room pressurization and assurance that the air is contained within the air-handling system/zone.

In addition, the ducted return system eliminates the opportunity for uncontrolled particulates (such as mold spores, construction dust remnants on top of ceiling panels, etc.) from entering the air-handling unit as part of the return air; however, it is believed this concern is without basis due to the requirements for final filters within the inpatient facility.

For outpatient facilities, ducted return systems are required for areas where pressure relationships are required. (The relative pressure relationships are specified in Table 7.1 of the standard). The requirement for ducted return systems for areas where pressure relationships are specified confirms the requirements established in the 2008 publication of Standard 170.

This requirement found large-scale acceptance by the design community, owners and staff. The ducted returns provide control of the air returned to the air-handling unit, allowing positive control of the room pressurization and positive control that the air is contained within the air-handling system/zone. Plenum returns are

allowed to serve other rooms where pressure relationships are not specified in the standard's Table 7.1.

However, there are a few exceptions to the requirement. The following additional surgery and critical care patient care areas shall also be served by fully ducted return or exhaust systems: recovery rooms; critical and intensive care areas; intermediate care areas; and wound intensive care units (burn units).

Gastrointestinal Endoscopy Procedure Rooms

While this room designation includes the nomenclature "procedure room," this room does not share the same ventilation requirements as a standard procedure room. One significant difference is that the procedure room requires 3 ach OSA and 15 total ach; whereas a GI procedure room has lesser requirements of 2 ach OSA and 6 total ach.

The "pressure relationship with adjacent spaces" (as listed in the standard's Table 7.1: Design Parameters) is now "N/R" (no requirement). This change reflects the current trend in health-care philosophy; wherein clinicians do not consider GI endoscopic procedures to be an invasive procedure. Containment, via negatively pressurizing the room with respect to adjacent areas, is not considered to be necessary since neither odors nor infectious aerosols are a concern.

The new requirement permits the room to be pressurized negatively, positively, or neutral relative to adjacent rooms and the corridor. The pressure relationship will be determined during design by the designer, clinical staff, owner and the ICRA team.

The salient facets of the current definition of invasive procedures are summarized as follows:

- An invasive procedure is a procedure that:
- Penetrates the protective surfaces of a patient's body (e.g., skin, mucous membranes, cornea);
 - Is performed in an aseptic surgical field (i.e., a procedure site);
 - Generally requires entry into a body cavity; and
 - May involve insertion of an indwelling foreign body ("indwelling" means implants such as pacemakers, joint replacements, etc.).

Patient Rooms

The minimum total air requirement for patient rooms is now 4 ach. The requirements in the 2008 edition had been 6 ach. This change was the result of the

committee's reassessment of the literature and research basis for the ventilation requirements. One key study⁵ indicates that 4 ach is the more appropriate value for a minimum standard.

AII/PE Rooms

Combination airborne infectious isolation/protective environment (AII/PE) rooms were first addressed in the *FGI Guidelines for Design and Construction of Health Care Facilities* in 2010. These rooms reflect the emergence of this need in health-care settings (refer to FGI 2010 for more information). "This type of room is for profoundly immunosuppressed patients with prolonged neutropenia (i.e., patients undergoing allogeneic or autologous bone marrow/stem cell transplants) who require a protective environment and have an airborne infectious disease."⁴ These rooms appear to be increasingly common, thus there is a need for definitive guidance for the ventilation and room pressurization requirements. The requirements stipulated in the standard are:

- a. "Supply air diffusers shall be located above the patient bed.
- b. Exhaust grilles or registers shall be located near the patient room door.
- c. The pressure relationship to adjacent areas for the required anteroom shall be one of the following:
 - The anteroom pressure shall be positive with respect to both the AII/PE room pressure and the corridor or common space pressure, or
 - The anteroom pressure shall be negative with respect to both the AII/PE room pressure and the corridor or common space pressure.
 - These rooms require positive pressurization, 2 ach (OSA) and 12 total ach."

The determination for selecting the most appropriate pressure relationship for the design of the anteroom is the responsibility of the design team and the ICRA team. Either design option provides an adequate barrier to separate the isolation room from the corridor.

Energy Recovery

Health-care facilities can be energy extensive buildings. Energy recovery can provide significant energy savings. (Refer to the *50% Advanced Energy Design Guide for Large Hospitals* and the *30% Advanced Energy Design Guide for Small Hospitals and Healthcare Facilities*.)

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Provisions for the application of energy recovery are now specifically addressed. The standard states: “If energy recovery systems are utilized, the systems shall not allow for any cross-contamination of exhaust air back to the supply airstream via purge, leakage, carryover, or transfer except as allowed in 6.8.3.” (see

sidebar “Energy Recovery Systems” for the text of 6.8.3). Runaround coils are one example of a system that is permitted.

Airborne infectious isolation (AII) room exhaust systems serving AII rooms or combination AII/PE rooms shall not be used for energy recovery. There is an

exception to this provision: systems may be served by an energy recovery system where the supply airstream components and the exhaust airstream components are separated by an air gap. This provides a strong assurance that the risk of cross-contamination is minimal.

Multiple Zones Calculations

“Multiple zone recirculating systems are systems that supply primary air to more than one ventilation zone and that recirculate air from one or more of the ventilation zones served.”⁷ Standard 170 addresses the methodology to calculate the outside air quantity for air supplied by the air-handling unit; for rooms with differing requirements for outdoor air, Standard 170 states:

6. For air-handling systems serving multiple spaces, system minimum outdoor air quantity shall be calculated utilizing one of the following methods:

i) System minimum outdoor air quantity for an air-handling system shall be calculated as the sum of the individual space requirements....

ii) System minimum outdoor air quantity shall be calculated by the Ventilation Rate Procedure (Multiple Zone Formula) of ASHRAE Standard 62.1. The Minimum Outdoor Air Change Rate listed in this Standard shall be interpreted as the V_{oz} (Zone Outdoor Airflow) for purposes of this calculation.

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It is believed that the majority of HVAC designs rely on calculating the sum of the individual space requirements. However, the multiple zone calculation methodology is appropriate for application in health-care facilities when a design warrants this approach. The benefit for considering this alternative is to ameliorate a design that over-ventilates a (air-handling unit) zone based on the requirements of one critical zone.

Recirculating Rooms Units

The standard has clarified the definition of “recirculating room units” and their applicability. “Recirculating room units” is esoteric terminology that has been ingrained in health-care ventilation design for more than 30 years. (For example, it was used in “Minimum Requirements of Construction & Equipment for Hospitals & Medical Facilities,” 1979.) The clarification in the standard addresses the following.

First, required outside air may not be introduced into spaces via recirculating room units, unless it is separately conditioned (heated, cooled, filtered). The intent of this requirement is to preclude the use of unitary systems that cycle on and off, and, therefore, provide ventilation air intermittently. In many cases, this may require a dedicated outdoor air system.

Second, to prevent microorganisms that may be present on a wet coil or in a condensate drain pan, from being introduced into the space, a MERV 6 filter is required downstream of any “surface designed to condense water.” It is important to note that the filtration requirements of Table 6.4 are only applicable to central air-handling systems (including dedicated outdoor air systems), not to recirculating room units.

Third, recirculating room units are only allowed to serve a single space. This is the provision that allows a MERV 6 filter to be used with a condensing surface, in lieu of a MERV 14 filter in these units. If an airborne particulate/contaminate issue develops in a space, it is confined to the space of origin, and not able to be transferred to another space via any return air path.

Fourth, and last, Standard 170 clarifies that air movement created by recirculating room units is able to be counted towards the Minimum Total Air Change Rate. For example, a dedicated outdoor air system could provide conditioned outside air to

Energy Recovery Systems

From Standard 170-2013, Section 6.8.3, *Energy Recovery Systems With Leakage Potential*. “If energy recovery systems with leakage potential are utilized, they shall be arranged to minimize the potential to transfer exhaust air directly back into the supply airstream. Energy recovery systems with leakage potential shall be designed to have no more than 5% of the total supply airstream consisting of exhaust air.

Energy recovery systems with leakage potential shall not be utilized from these exhaust airstream sources: ER waiting rooms, triage, ER decontamination, radiology waiting rooms, darkroom, bronchoscopy sputum collection and pentamidine administration, laboratory fume hood and other directly ducted laboratory equipment exhaust, waste anesthesia gas disposal, autopsy, nonrefrigerated body holding, endoscope cleaning, central medical and surgical supply soiled or decontamination room, laundry general, hazardous material storage, dialyzer reprocessing room, nuclear medicine hot lab, nuclear medicine treatment room, and any other space identified by the Authority Having Jurisdiction or the ICRA team.”²

four-pipe fan-coil units. The amount of outside air calculated for each unit/space must meet or exceed the Minimum Outside Air Change Rate. However, the total airflow required to achieve Minimum Total Air Change Rate (or the amount required to meet this requirement, plus any other of the space’s needs) may be recirculated within the space via the fan-coil unit fan. A similar system could use active chilled beams as the recirculating room units. This approach has been deemed acceptable due to studies that have shown that supplying this air from outside the space does not provide any further reduction of contaminants in the breathing zone.

Displacement Ventilation

Displacement ventilation has received significant attention in building designs in recent years. The 2008 edition of Standard 170 precluded the use of this type of system in many spaces by mandating (in Table 6-2) that air be supplied from the ceiling. A major health-care provider commissioned research to determine if displacement ventilation could be applied in health-care settings. Based, in part, on this research, the standard now permits low sidewall supply diffusers to be used in single patient rooms (in Table 6.7.2, Supply Air Outlets).

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Several caveats were attached to the use of displacement ventilation systems in this addendum:

1. A minimum of 6 total air changes is required. However, this airflow can be calculated based on the volume of the room from the floor, up to 6 ft (1.8 m), not all the way to the ceiling.

2. Diffusers must be located where they cannot be blocked by equipment or furniture.

3. Return/exhaust grilles must be located at ceiling level, approximately above the head of the patient bed.

4. Transfer grilles for the toilet room must be located above the occupied zone.

(Items 3 and 4 are intended to facilitate the removal of contaminants from the breathing zone.)

Duct Lining

For many years, the Guidelines for Design and Construction of Health Care Facilities^{4,6} prohibited the use of duct lining in systems serving certain critical areas (operating rooms, delivery rooms, labor/delivery/recovery rooms, nurseries, protective environment rooms, and critical care units). Lining in terminal units and sound attenuators was allowed as long as it was protected with a “special covering.” The concern was particulate matter, and other contaminants that might grow on the lining, being allowed into these critical areas.

When ASHRAE Standard 170 was published in 2008, it did not include any requirements regarding duct lining. The standard has been revised to allow duct lining as long as it was located upstream of the final filters (Filter Bank 2). The standard allows lining in terminal units and sound attenuators downstream of the final filters if they have an impervious cover. For quality control reasons, this cover is required to be factory installed.

Residential Health-Care Filtration

The 2006 FGI Guidelines required two banks of filtration for nursing facilities (MERV 7/ MERV 13). This requirement

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was omitted from the 2010 Guidelines, and not included in Standard 170. From 2010 through 2013, the committee extensively discussed the need for two banks of filters with the residential health-care community. The standard now requires one filter (MERV 13) in systems serving these facilities. This provides good filtration of the air supplied to residents; although without the benefit of a first filter bank to provide improved longevity of the MERV 13 filter.

The standard now also addresses the filtration requirements for inpatient hospice facilities and assisted living facilities. Inpatient hospice facilities require MERV 13 filters. (This refers to hospice care within an inpatient facility, e.g., hospital.) Assisted living facilities require MERV 7 filters. The standard does not currently address other types of residential care settings such as adult day care, etc.

Summary and Updates

The standard has evolved considerably since 2008. The ASHRAE committee, SSPC 170, has issued 24 addendums over this period of time. The committee feels that each addendum has improved the standard with respect to clarity, energy efficiency, practical engineering design, and infection control and prevention.

The committee membership strives to have expertise in a broad range of facets related to the design of health-care facilities; while maintaining a manageable size. The committee membership includes the expertise from hospital facility managers, health-care facility authority's having jurisdiction, infection preventionists, designers, manufacturers and contractors. The committee has broad ties that include the Facility Guidelines Institute (that governs the publication of the *Guidelines for Design and Construction of Health Care Facilities*), ASHE, (Florida) Agency for Health Care Administration, Association of Professionals in Infection Control, and the Association of Operating Room Nurses.

Standard 170-2008 was incorporated within the *Guidelines for Design and Construction of Health Care Facilities 2010*. Standard 170-2013 Ventilation of Health Care Facilities has been incorporated in the *Guidelines for Design and Construction of Hospitals and Outpatient Facilities, 2014*. Similarly, it is planned that Standard 170 will be incorporated

in the *Guidelines for Design and Construction of Residential Health, Care, and Support Facilities, 2014*.

The development of Standard 170 allowed ASHRAE to remove its provisions for ventilation of health-care facilities from Standard 62.1, *Ventilation of Acceptable Indoor Air Quality*. This occurred in June 2009. This eliminated the conflict between the two ASHRAE standards.

ASHRAE Standard 170 is also gaining national acceptance amongst the model codes. ASHRAE Standard 170-2008 has been adopted into the International Mechanical Code (IMC), and will be incorporated within the 2015 publication of the IMC. A proposal to incorporate a reference into the Uniform Mechanical Code (UMC) has been issued for public review in the fall of 2013. (The model codes will need additional time to review and consider adoption of Standard 170-2013.)

Another standard, NFPA 99, *Health Care Facilities*; requires that heating, cooling and ventilation be provided in accordance with Standard 170.

The recently republished Standard 170 -2013 offers improved clarity over the original standard. It will continue to assist the design team, owners and operators of health-care facilities and benefit the patients, visitors and clinical staff.

At the time of this publication, Addendum *a*, regarding packaged rooftop units and Addendum *b* regarding the references are being processed for public review.

References

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