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Airborne Infectious Disease:

Best Practices for Ventilation Management

The latest guidance and advice for emerging infectious disease preparedness and control.

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Control measures for airborne infectious diseases are invaluable in health-care facilities that treat patients with these afflictions. These hospitals may also need to treat immunocompromised patients, such as solid organ transplant recipients, or those being treated for blood cancers. Verification of these special ventilation conditions requires a thorough understanding of the design and maintenance of the requisite specifications in order to provide the appropriate ventilation parameters for protective environment patient rooms (See Table 1).

VENTILATION REQUIREMENTS

The initial cost of ventilation equipment versus future maintenance requirements is just one factor of what cost should be considered for hospital facility management. Sustainability of health-care buildings is maintaining the building to the specification to which it was designed. Today's patient care challenges include emerging infectious diseases, some of which are airborne. Some of these diseases, such as aspergillosis, only affect patient populations, but others, such as tuberculosis, prey on heath-care workers, as well.

The management of the mechanical systems in health-care becomes critical for the safe environment of care. Issues relating to the building envelope are critical to proper infection control. For example, maintaining the window seal and the management of the pressure relationships of a building are both essential in the management of infectious diseases. Construction and maintenance of ventilation systems should be designed to provide consistent air exchanges for dilution ventilation and the exhaust of airborne hazards.

The pressure relationships between inside and outside the building or between different interior spaces is needed to mitigate the migration of airborne hazards. Filtration with greater than 90 percent efficiency (>MERV14) will physically remove the airborne particles at greater than 99 percent efficiency if the particles are greater than 1.0 µm in diameter.

Ultraviolet (UV) light is an air disinfectant,

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which may have application as supplemental engineering controls under certain conditions. However, suggestive clinical or epidemiological studies do not totally support the use of UV in health-care facilities, therefore the recommendation is marginal as a category II rating by the Centers for Disease Control and Prevention (CDC) in its recent "Guidelines on Environmental Infection Control." [1] Such options must be carefully considered for the long term safety in health-care facilities. Source control is the essence of managing infections. Therefore the principal of source management as it pertains to the potential sources of the infectious agent must be understood and should be applied as an analysis for hazard reduction.

Another relatively new consideration is bioterrorism. A hospital that protects its patients from common biological agents should be able to protect patients from bioterror activity.

Ventilation parameters	Airborne infection	Protective environment
Air changes per hour	More than 12	More than 12
Filtration		
Supply	90% dust spot	99.97% at 0.3 μm
Return	99.97% at 0.3 μm	Back through filter or 100% exhaust
Toilet	100% exhaust	100% exhaust
Supply versus exhaust offset	More than 125 cfm	More than 125 cfm
Air-flow direction	Into room	Out of room
Pressure differential	Over 0.01-in WG	Over 0.01-in. WG
Minimum room leakage	Less than 0.5 sq ft.	Less than 0.5 sq ft.

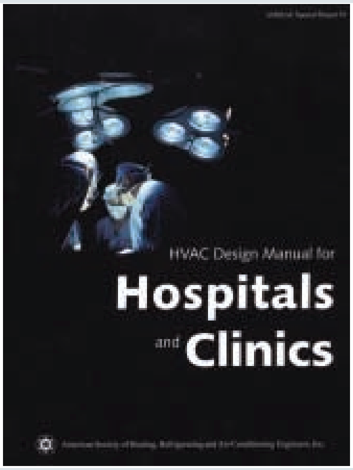
TABLE 1. Commissioning guidelines for special-ventilation rooms in health-care settings.

Two New Hospital Ventilation Guidelines

Two recent guidelines have been made available to help hospitals manage ventilation for infectious disease control.

The Centers for Disease Control and Prevention (CDC) published Guidelines for Environmental Infection Control in Health-Care Facilities.[1] These guidelines provide the recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). The contents of this document include the rationale for recommendations and rating for issues relating to air, water, environmental services, environmental sampling, laundry and bedding, animals in health-care facilities and regulated medical wastes.

The document is quite specific in the performance measurements that need to be established to assure ventilation control of airborne infectious diseases. It emphasizes the risks involved with immunocompromised patients, a diverse patient population that is growing rapidly. Because of this fact ,the CDC felt that the guidelines should include recommendations for cleaning, maintenance, water quality and ventilation. The documents discusses the need to provide immediate response to water intrusion to avoid mold growth. Such contamination can lead to infection in immunocompromised patients. The CDC Environmental



Infection Control is free for download from www.cdc.gov.

This document took three- plus years to compile due to the massive volume of information that needed to be gathered and verified. At the same time, the ASHRAE SP-91 team was compiling a the "HVAC Design Manual for Hospitals & Clinics" which is now available for purchase from ASHRAE (*www.ASHRAE.org*). The manual provides best practice design considerations for operators of mechanical systems. The intent of the book was to gather experienced writers and reviewers to compile the design considerations for a variety of operational considerations

Topics include essential terminology, HVAC design criteria, design for existing facilities, cooling and heating plants, controls for mechanical systems, life safety considerations, room design, operation and maintenance, commissioning guidelines, and energy conservation. This book provides one of the most comprehensive overviews of mechanical system management in a health-care facility ever published.

With these two documents, a building manager will have some of the most timely, state-of-the-art information available to manage the ever-changing climate in dynamic health-care world. The challenges of building management are formidable: disaster planning, bio-defense, and infectious disease management.

INFECTION CONTROL GUIDELINES

Pressure should be the key factor for ventilation-control of infectious agents However, pressure management in health care is focused on fire and smoke control. Infectious disease management has often ignored pressure management especially as it pertains to consistent airflow. Too often, fan belts slip, windows are left open or doors not closed—all of which prevent consistent pressure management. When such breeches occur, it means that pressure management for airborne infectious diseases will not work. For example, a renovation job several years ago at a patient-care hospital required that walls be opened for the construction of an elevator. In this case, one of the only control measures was to close the outside doors at the construction site, but not even this was done. As a result, there was a cluster of infections at a major hospital.[2]

GENERAL ADVICE

In order to achieve the desired pressure relationships in rooms, common mistakes should be avoided.

• Air volume offsets between supply and exhaust/return are designed too low to achieve the recommended pressure relationship of greater than 0.01 in. wg for airborne infection isolation and protective environments. The offset of supply versus exhaust/return air volume should be greater than 125cfm in a standard 1,200 sq ft room. The rooms should be designed with that offset and the room leakage points should be sealed to less than 0.5 sq ft total leakage area. Once the room ventilation is functioning as designed, the monitoring of the rooms can be activated, according to the Architectural Institute of America guidelines. [3] According to this guide, special ventilation rooms for isolating airborne infectious patients (AII) and protecting patients should have a permanently installed visual monitoring system of the airflow direction. These monitoring systems can be mechanical or electronic but do not need to be alarmed. If alarms are installed, allowances should be made to prevent nuisance alarms of the monitoring system. The rooms,if properly designed with the appropriate air volume offset should not have nuisance alarms, but allowances for a time delay before alarm activation is necessary to allow for the opening of doors in the special ventilation rooms.

• Room leakage is an important factor because the offset between supply and exhaust/return will—if the leakage area is too large—decrease the pressure due to inflow or outflow of air to paths of air with less resistance, such as through improperly sealed windows.. Excessive infiltration would not allow for adequate depressurization of the airborne infection-isolation room for isolating patients in that room who may have active tuberculosis.

• With other conditions , such as during construction, risk assessments for excavation or demolition next to a hospital with immunocompromised patients may be at risk due to the pressurization of the critical care buildings. For example, if more air is exhausted in the building than is supplied, a pressure imbalance will occur. This will happen in high rise (greater than 6 stories) building because of the stack effect when warm air rises in a building. Such conditions can bring air into the critical-care hospital that does not get filtered or dehumidified by the air handling system. Such conditions can create condensation water on cool surfaces providing ideal mold growth conditions. The depressurization of the building can also allow unfiltered air into the building, which probably contains *Aspergillous* spores, which are opportunistic pathogens to certain patients.

• When pressure management is needed, operable windows, open doors and building connections can cause building pressure problems. During a recent evaluation, the source of irritating particles in patient-care areas was from a boiler room, due to a building ventilation imbalance. That building required an immediate air balance analysis to correct what was found to be an extreme building pressure imbalance. The hospital on the day of that evaluation was depressurized to 6 Pascal's (0.025-in. wg), which represents air velocity into the building through openings in excess of 500 linear ft per min.

• Maintenance priorities are always an issue for any system, but an absolute must for infection control management.[4]

• In some emergency rooms, a single switch was designed to exhaust the ER area to provide for immediate isolation of the ventilation in waiting areas and rooms. Such switches are not recommended for the all-purpose isolation rooms,such areas would allow for switching from protective to airborne infections rooms. The AIA does not recommend this practice due to the sophisticated controls needed and the number of nonfunctioning rooms which were discovered when tested. In some hospital ERs, it is possible to create airborne-infection bays to provide the appropriate ventilation airflow by simply closing the door. According to the National Bioterrorism Hospital Preparedness Program 2003, it is desirable for the hospital to have at least one airborne infection room per hospital participating in the program.[5] The facility selected should have the capability to treat 10 adult and pediatric patients. With such a request, it will be necessary for selected hospitals to have negative-pressure environments which include isolation wards. Many hospitals have isolation rooms due to the resurgence of tuberculosis in the early 1990s. These rooms should meet the AII room criteria, which is listed above.

MONITORING

Monitoring devices are intended to maintain awareness changes that might affect critical features of the ventilation system. Such critical areas include AII and protective environments (PE). These rooms are required to be monitored. The use of smoke sticks is recommended as a visual check, but a mechanical monitoring systems, such as flutter strip or ball in a tube system, are capable of demonstrating appropriate airflow direction when the door is closed.Testing of such visual equipment can be accomplished simply by opening and closing the door of the room. Such visual systems will show that the ball moves across the opening during the door movement just like smoke movement when the door is closed. Likewise, electronic systems should zero under the same test method and digitally demonstrate zero when to door is open or a level of pressure greater than 2.5 Pascals (0.01-in. wg) when the door is closed.

Some electronic systems can plug with lint after some time, therefore they should be routinely checked for accuracy with another calibrated pressure-testing device. The AII rooms should be checked at least monthly and if infectious patients are housed in the AII rooms they should be checked daily. A visual monitor would be assuring because of the simple test validating movement of a flutter strip or ball. Maintenance cost must be included if the utilization of electronic monitoring devices is considered.

USING EXISTING ISOLATION SYSTEMS

As previously stated there should be a cost effective way to establish zones for airborne isolation of many patients in one place in a hospital. With modern hospital ventilation units, we need to look to existing systems to provide such management of multiple cases of infectious patients. There are smoke zones already mandated to manage fire and smoke within the health-care structure. These zones are set up to evacuate the smoke if fires occur. The zone is fire stopped to prevent smoke movement between zones. These barriers are air tight enough to allow for potential isolation of many beds within the hospital. The individual rooms within that zone might not be capable of being depressurized but with closed doors and zone exhaust capability, this space could be effectively isolated from the other parts of the health-care facility Such zones exist and are tested for fire management routinely. These "natural" zones are also used to isolate construction projects in order to manage the aerosols generated by construction and renovation. We do this by using the balance dampers to help depressurize the area by reducing the supply air. The complete exhaust of that zone becomes a challenge but can be accomplished.

SAFE STORAGE OF PROTECTIVE GEAR

Providing areas for the storage of infectious-disease personal protective equipment (PPE) is important. These storage areas will be required due to potential "super shedder" concerns for environmental contamination during the recent SARS outbbreak. The mode of transmission of SARS is not certain especially whether the SARS virus is airborne or droplet/contact spread. Emerging infectious diseases, like SARS, will require thoughtful, cost-effective preparedness for the environment.

EMERGENCY PREP AREAS

ER triage and waiting areas are needed to quickly identify patient problems as they arrive in the hospital. Such areas should have isolation capability for chemical decontamination or infectious disease control. The triage indication of airborne infectious disease should dictate the immediate isolation of that patient in an airborne-isolation condition with appropriate ventilation parameters to contain any release of infectious droplet nuclei. Many ERs are equipped to handle one or two such patients. But what happens if many patients show up with suspicious symptoms? Enlightened architects are providing ERs with waiting areas that can be separated with simple room dividers having exhaust ducts on one side of the divider and a supply air duct on the other. Larger numbers of contaminated patients may be housed on the side with the exhaust with airflow into that area exhausting to the outside. Some of these ERs have a switch on the wall to create a complete depressurization of the ER if needed.

CONCLUSION

Anticipation of the problems associated with infection control should focus on the existing issues for controlling airborne spread diseases such as aspergillosis and tuberculosis. These are two examples of the problems which realistically could plague a facility if they are not prepared. In preparation the principals of infectious disease management must be focused on the condition of the mechanical systems and where the risk is expected. The preparation must consider what can be accomplished for minimizing the risk to patients and employees. The National Bioterrorism Hospital Preparedness Program is developing the cooperative agreement with states to develop a plan for management of terrorist associated disease. The current exposure problems with know infectious agents if handled with basic of principals of ventilation management will help to prepare for the unthinkable.

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