Ventilation for Energy Management and Infection Prevention
Andrew Streifel, University of Minnesota Medical Center
A Webber Training Teleclass

Ventilation for Energy Management and Infection Prevention
Andrew Streifel
Hospital Environment Specialist
University of Minnesota Medical Center

Hosted by Dr. Lynne Sehulster
Centers for Disease Control, Atlanta

www.webbertraining.com

Andrew Streifel
Hospital Environment Specialist
University of Minnesota Medical Center

• 38 years service at U of Minnesota infection prevention.
• Visited over 400 hospitals & assisted in IAQ infection issues.
• Technical expert for ASHRAE, CDC, FGI & other organizations.
• Goal to provide evidence based training for prevention of infections during construction & maintenance practice.
• Provide guidance for infectious disease prevention design concepts.

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Why is energy important to infectious disease management?

- Mermazadeh and Xu 2012 recommend site specific risk analysis because increasing or decreasing the room air exchange rate by as little as one air change per hour can result in a difference of $150-250 per year in heating and cooling costs for that room.

Dr. Mermazadeh is the Director of Technical Services NIH.

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### Electrical Usage at Typical Hospital

<table>
<thead>
<tr>
<th>Process</th>
<th>Consumption %</th>
<th>Dollars $</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>14</td>
<td>$198,800</td>
<td>4</td>
</tr>
<tr>
<td>Misc. Electrical</td>
<td>15</td>
<td>$213,000</td>
<td>3</td>
</tr>
<tr>
<td>Outdoor Air Cooling</td>
<td>5</td>
<td>$71,000</td>
<td>7</td>
</tr>
<tr>
<td>Space Cooling</td>
<td>17</td>
<td>$241,400</td>
<td>2</td>
</tr>
<tr>
<td>Fan Heat/Losses</td>
<td>5</td>
<td>$71,000</td>
<td>7</td>
</tr>
<tr>
<td>Cooling Tower/Cond. Pumps</td>
<td>9</td>
<td>$127,800</td>
<td>5</td>
</tr>
<tr>
<td>CW &amp; HW Pumps</td>
<td>6</td>
<td>$85,200</td>
<td>6</td>
</tr>
<tr>
<td>Ventilation Fans</td>
<td>24</td>
<td>$340,800</td>
<td>1</td>
</tr>
<tr>
<td>Heating Auxillaries</td>
<td>5</td>
<td>$71,000</td>
<td>7</td>
</tr>
</tbody>
</table>

An electric energy usage profile for a hospital in Houston (500,000 SF X $2.84/SF electric = $1,420,000/year utility cost).
Gas Consumption in a Typical Hospital

<table>
<thead>
<tr>
<th>Process</th>
<th>Consumption %</th>
<th>Dollars $</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor-Air Heating</td>
<td>7</td>
<td>$32,900</td>
<td>3</td>
</tr>
<tr>
<td>Reheat</td>
<td>65</td>
<td>$305,500</td>
<td>1</td>
</tr>
<tr>
<td>Space Heating</td>
<td>15</td>
<td>$70,500</td>
<td>2</td>
</tr>
<tr>
<td>DHW Heating</td>
<td>3</td>
<td>$14,100</td>
<td>5</td>
</tr>
<tr>
<td>Dietary/Sterilizers</td>
<td>5</td>
<td>$23,500</td>
<td>4</td>
</tr>
<tr>
<td>Distribution Losses</td>
<td>5</td>
<td>$23,500</td>
<td>4</td>
</tr>
</tbody>
</table>

A thermal energy usage profile for a hospital in Houston (500,000 SF x $0.94/SF gas = $470,000/year utility cost).

Levels of Risk

Healthy person
- Chronic obstructive pulmonary disease
- Diabetes
- Steroids
- Cancer - solid tumor
- HIV infection-end stage of spectrum
- Organ transplant
  - Kidney/heart
  - Lung/liver
- Malignancy - leukemia/lymphoma
  Bone marrow transplant (BMT) allograft
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What Drives High Energy Use in Healthcare Facilities

- Ventilation
  - High Efficiency Filters
    +90 to 99.97% efficiency

- Indoor Air Quality Standards
  - 12 to 20 room air exchanges per hour
  - Waste anesthetic gas, heat, electro-cautery smoke
  - Microbial shedding and surgical aerosols (no standards)

- Airborne Infection, Protective Rooms, ICU’s and Surgery
  - High air exchanges for heat and aerosol control some recirculate
  - Exhaust from airborne isolation rooms

- IAQ control for temperature, humidity, minimum outdoor air

- Domestic water temperatures

- Laboratory equipment

- Therapeutic and Diagnostic equipment

- 24/7/365 100% ready days with emergency backup


Annual morbidity: 721,800 – Decrease from 1.7 million estimated in 2002 (NEJM, 2014)

- 1 in every 25 inpatients has at least 1 HAI
- Most common: Pneumonia and surgical site infection
- Most frequent organism: Clostridium difficile

Annual mortality: 100,000 estimated in 2002 (Klevens, Public Health Reports, 2002)

Direct costs associated with HAI: $28.4-$45 Billion (Scott, CDC Paper, 2012)

Incidence associated with construction unknown; multiple outbreak papers published

<table>
<thead>
<tr>
<th>Major Site of Infection</th>
<th>Estimated No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>157,500</td>
</tr>
<tr>
<td>Gastrointestinal Illness</td>
<td>123,100</td>
</tr>
<tr>
<td>Urinary Tract Infections</td>
<td>93,300</td>
</tr>
<tr>
<td>Primary Bloodstream Infections</td>
<td>71,900</td>
</tr>
<tr>
<td>Surgical site infections from any inpatient</td>
<td>157,500</td>
</tr>
<tr>
<td>Other types of infections</td>
<td>118,500</td>
</tr>
<tr>
<td>Estimated total number of infections in hospitals</td>
<td>721,800</td>
</tr>
</tbody>
</table>

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Factors Involved in the Spread of Infectious Diseases

- Droplet nuclei transmission dynamics
- Nature of dust levels
- Health & condition of individual’s nasopharyngeal mucosal lining
- Population density in a particular location
- Ventilation of the location

Standard Precautions Against Disease Transmission

- Early identification of microbes
- Development of appropriate SOPs
- Use of PPE including:
  - Masks & gloves
  - Disinfection strategies
  - Vaccination
  - Appropriate ventilation design
Indoor Air Quality

Three Kinds of Contaminants
- Particles
  - Dust
  - Allergens
  - Smoke
- Gases
  - Chemicals
  - VOCs
  - Odors
- Micro-Biological
  - Virus
  - Bacteria
  - Spores

Organisms Associated with Airborne Transmission

<table>
<thead>
<tr>
<th>Category</th>
<th>Fungi</th>
<th>Bacteria</th>
<th>Viruses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous reports in HCF</td>
<td>Aspergillus spp. Mucorales</td>
<td>M. tuberculosis</td>
<td>Measles virus Varicella-zoster virus</td>
</tr>
<tr>
<td>Airborne in nature; airborne transmission in HCF not described</td>
<td>Coccidioides immitis Cryptococcus spp. Histoplasma capsulatum</td>
<td>Coxiella burnetti (Q fever)</td>
<td>Hantaviruses Lassa virus Marburg virus Ebola virus Crimean-Congo Virus</td>
</tr>
</tbody>
</table>

CDC Guideline for Environmental Infection Control Guidelines 2003
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Aspergillus fumigatus
• prolific spore production

Aerodynamic spore
2-4μm diameter

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Recent examples of the frequency of invasive aspergillosis

<table>
<thead>
<tr>
<th>Underlying condition</th>
<th>Incidence</th>
<th>Reference/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute myeloid leukaemia</td>
<td>8%</td>
<td>Cornet, 2002</td>
</tr>
<tr>
<td>Acute lymphatic leukaemia</td>
<td>6.3%</td>
<td>Cornet, 2002</td>
</tr>
<tr>
<td>Allogeneic HSCT</td>
<td>11-15%</td>
<td>Grow, 2002; Marr, 2002</td>
</tr>
<tr>
<td>Lung transplantation</td>
<td>6.2-12.8%</td>
<td>Minari, 2002; Singh, 2003</td>
</tr>
<tr>
<td>Heart-lung transplantation</td>
<td>11%</td>
<td>Duchini, 2002</td>
</tr>
<tr>
<td>Small bowel transplantation</td>
<td>11%</td>
<td>Duchini, 2002</td>
</tr>
<tr>
<td>AIDS</td>
<td>2.9%</td>
<td>Libanore, 2002</td>
</tr>
</tbody>
</table>

How far can Airborne Bacteria & Viruses Travel?

1. Coughing                      1-5 feet  160+ feet
2. Sneezing                      8-15 feet 160+ feet
3. Singing, Talking              1-3 feet  160+ feet
4. Mouth Breathing               1-3 feet  160+ feet
5. *Diarrhea                     5 feet+  160+ feet

*As a Result of Toilet Water Aerosolization and Mechanical Fan Dispersion into outdoor air (2003 Hong Kong SARS Virus Epidemic)
Stages of Infectious Droplets & Droplet Nuclei

1. Mucus/water encased by the infector or by toilet water. These quickly fall to the ground after traveling up to 1-3 feet.

2. Mucus/water coating starts to evaporate. These will travel 3-5 feet before falling to the ground. These droplets can become droplet nuclei.

3. Mucus/water coating has totally evaporated coating the viron particles. These are Droplet Nuclei which are so microscopic they can float in the air.

### Evaporation Time & Falling Distance of Droplets Based on Size

<table>
<thead>
<tr>
<th>Diameter of Droplet (µm)</th>
<th>Evaporation time (sec)</th>
<th>Distance fallen in ft. (before evaporation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>5.2</td>
<td>21.7</td>
</tr>
<tr>
<td>100</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>50</td>
<td>0.31</td>
<td>0.085</td>
</tr>
<tr>
<td>25</td>
<td>0.08</td>
<td>0.0053</td>
</tr>
</tbody>
</table>


*particles discharged at 6 ft. > 140µm tend to fall to the ground

*particles discharged at 6 ft. < 140µm evaporate to droplet nuclei

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Infectious Droplets & Droplet Nuclei travel lengths

Airborne Transmission depends on people to launch viruses into the air.

People can shed this many Flu Viruses into the air as tissue culture infecting doses (TID)

1. Coughing       3,000+ TID
2. Sneezing       3,000+ TID
3. Breathing:    Nose-None
4. Talking/Singing 1,000+ TID
5. Vomiting      1,000+ TID
6. *Diarrhea     20,000+ TID

* As a result of Toilet Water Aerosolization
Low Indoor Humidity Increases Droplet Nuclei Levels (winter)

- Viruses Evaporate faster in Low Humidity levels thus creating More Droplet Nuclei.
- Low humidity allows droplet nuclei to stay airborne longer as the droplets do not absorb water weight which would cause them to fall to the ground.
- Indoor Air currents both created by HVAC systems and people movement assure that droplet nuclei will remain airborne Indefinitely.
- This allows HVAC systems to remove and redistribute droplet nuclei throughout the building to infect more occupants.
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There is a DIRECT correlation between low indoor humidity in winter and increases in influenza morbidity and mortality

1) Indoor humidity levels (winter) in the Northern Hemisphere especially in North America and Europe are between 15-35%.

2) Studies have proven that there is no “flu season” in the tropics where indoor humidity levels stay above 40% all year long.

Facility Guidelines Institute

<table>
<thead>
<tr>
<th>Function of Space</th>
<th>Relative Humidity %</th>
<th>Design Temperature °F/°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classes B &amp; C Operating Rooms</td>
<td>20-60</td>
<td>68-75/20-24</td>
</tr>
<tr>
<td>Burn unit</td>
<td>40-60</td>
<td>70-75/21-24</td>
</tr>
<tr>
<td>Newborn intensive care</td>
<td>20-60</td>
<td>70-75/21-24</td>
</tr>
<tr>
<td>Patient room(s)</td>
<td>max 60</td>
<td>70-75/21-24</td>
</tr>
<tr>
<td>Protective environment room</td>
<td>max 60</td>
<td>70-75/21-24</td>
</tr>
<tr>
<td>Airborne Isolation anteroom</td>
<td>N/R</td>
<td>N/R</td>
</tr>
</tbody>
</table>

ASHRAE STD 170 HEALTHCARE VENTILATION 20% RH CHANGE

ASHRAE Standard 55-1992 recommends: Relative Humidity between 20% and 60%
Less than 50% RH for dust mite control

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There are six basic types of natural ventilation systems:
- single-side corridor
- central corridor
- courtyard
- wind tower
- atrium and chimney
- hybrid (mixed-mode) ventilation.

4.2 Ventilation flow rate

As a rule of thumb, wind-driven natural ventilation rate through a room with two opposite openings (e.g. a window and a door) can be calculated as follows:

\[
\text{ACH} = \frac{0.65 \times \text{wind speed (m/s)} \times \text{smallest opening area (m}^2) \times 3600 \ \text{s/h}}{\text{room volume (m}^3)"

Ventilation rate (l/s) = 0.65 \times \text{wind speed (m/s)} \times \text{smallest opening area (m}^2) \times 1000 \ \text{l/m}^3

Table 4.1 provides estimates of the ACH and ventilation rate due to wind alone, at a wind speed of 1 m/s, assuming a ward of size 7 m (length) \times 6 m (width) \times 3 m (height), with a window of 1.5 \times 2 m\) and a door of 1 m\^2 \times 2 m\) (smallest opening).

<table>
<thead>
<tr>
<th>Openings</th>
<th>ACH</th>
<th>Ventilation rate (l/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open window (100%) + open door</td>
<td>37</td>
<td>1300</td>
</tr>
<tr>
<td>Open window (50%) + open door</td>
<td>28</td>
<td>975</td>
</tr>
<tr>
<td>Open window (100%) + closed door</td>
<td>4.2</td>
<td>150</td>
</tr>
</tbody>
</table>
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Figure 5.5 Wind-driven natural ventilation in the single-side corridor type hospital with wind entering the corridor

Figure 5.6 Combined wind and buoyancy-driven natural ventilation in the courtyard type (inner corridor) hospital

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Table 5.1 Potential applicability of natural ventilation solutions in ideal conditions (consensus of a WHO systematic review)

<table>
<thead>
<tr>
<th>Climate</th>
<th>Natural ventilation</th>
<th>Hybrid</th>
<th>Mechanical ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single-sided corridor</td>
<td>Stack (atrium/chimney)</td>
<td>Courtyard</td>
</tr>
<tr>
<td>Hot and humid</td>
<td>★ ★ ★ ★</td>
<td>★ ★ ★</td>
<td>★ ★ ★ ★ ★ ★ ★ ★</td>
</tr>
<tr>
<td>Hot and dry</td>
<td>★ ★ ★ ★</td>
<td>★ ★ ★ ★</td>
<td>★ ★ ★ ★ ★ ★ ★ ★</td>
</tr>
<tr>
<td>Moderate</td>
<td>★ ★ ★ ★</td>
<td>★ ★ ★ ★</td>
<td>★ ★ ★ ★ ★ ★ ★ ★</td>
</tr>
<tr>
<td>Cold</td>
<td>★ ★ ★ ★</td>
<td>★ ★ ★ ★</td>
<td>★ ★ ★ ★ ★ ★ ★ ★</td>
</tr>
</tbody>
</table>

Note: The actual achievement is not always up to the potential and care must be taken with all ventilation designs in the critical setting of health-care facilities with airborne infectious agents known or expected to be present.

Applicability of natural ventilation systems

★ The performance is in either thermal comfort or infection control is unsatisfactory. In terms of infection control, it means the magnitude of the ventilation rate.

★★ The performance is fair.

★★★ The performance is acceptable, but compromise may be needed in terms of thermal comfort.

★★★★ The performance is good in terms of both thermal comfort and airborne infection control.

★★★★★ The performance is very good (satisfactory) in terms of both thermal comfort and infection control.

Natural ventilation for infection control in health-care settings.

Negative Pressure Room for Airborne Infection Isolation

Positive Pressure Room for Protective Environment

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Table 6. Engineered specifications for positive- and negative pressure rooms*

<table>
<thead>
<tr>
<th>Positive pressure areas (e.g., protective environments [PE])</th>
<th>Negative pressure areas (e.g., airborne infection isolation [AI])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure differentials &gt; +2.5 Pa (0.01&quot; water gauge)</td>
<td>&gt; -2.5 Pa (0.01&quot; water gauge)</td>
</tr>
<tr>
<td>Air changes per hour (ACH) &gt;12</td>
<td>&gt;12 (for renovation or new construction)</td>
</tr>
<tr>
<td>Filtration efficiency: Supply: 99.97% @ 0.3 μm DOP*</td>
<td>Supply: 99.97% @ 0.3 μm DOP*</td>
</tr>
<tr>
<td>Filtered: 90% (dust spot test) Return: none required**</td>
<td>Return: 99.97% @ 0.3 μm DOP*</td>
</tr>
<tr>
<td>Room airflow direction: Out to the adjacent area</td>
<td>In to the room</td>
</tr>
<tr>
<td>Clean-to-dirty airflow in room: Away from the patient (high-risk patient, immunosuppressed patient)</td>
<td>Towards the patient (airborne disease patient)</td>
</tr>
</tbody>
</table>

**Ideal pressure differential**

- + 8 Pa
- > -2.5 Pa

* Material in this table was compiled from references 35 and 120. Table adapted from and used with permission of the publisher of reference 35 (Lippincott Williams and Wilkins).

\* Pa is the abbreviation for Pascal, a metric unit of measurement for pressure based on air velocity. 250 Pa equals 1.0 inch water gauge.

\* DOP is the abbreviation for diocetylphthalate particles of 0.3 μm diameter.

** If the patient requires both PE and AI, return air should be HEPA-filtered or otherwise exhausted to the outside.

1. HEPA filtration of exhaust air from AI rooms should not be required, providing that the exhaust is properly located to prevent re-entry into the building.

AIA & ASHRAE DESIGN GUIDELINES FOR VENTILATION

Ventilation:

PROPOSED ENERGY EFFICIENCIES

- Displacement
- Chill beams
- Heat wheels
- Minimal leakage

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- Exterior Testing
  - Water proof
  - Air infiltration
  - Condensation
  - Cooling
  - Heating
  - Structural

Condensation Prevention
- Dynamic Testing
  - Use pipe grid system to spray water
  - Use a propeller engine to simulate wind conditions
  - At 12 PSF for 15 minutes
  - Check for leaks

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Thermal Testing by Cooling

Thermal Testing by Heating

Planning for New Ambulatory Care Center University of Minnesotan Medical Center 2014

Benefits of Active Beams in Healthcare
- Reduction in air handling equipment
- Minimization and elimination of ductwork
- Reduction in reheat
- Quiet operation
- Improved indoor air quality
- Reduced risk of cross contamination

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Chill beam advantage is to separate the cooling component with the air supply to save energy.

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Figure 2: Schematic operation of an active chilled beam.

- Must have access for cleaning
- Must not condense on the surfaces of the chill beam
- A sealed curtain wall helps keep humidity out of the building

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What is displacement ventilation?

Displacement like piston airflow moves air in a single direction that displaces air as it moves. The intent being not to mix the air but pushes it.

Normal Room Ventilation Conditions

Short circuiting airflow

Mixing ventilation

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Energy saving and moving air out of the breathing zone

In a displacement ventilation system, warmer air enters through vents near the floor, then rises and exits through exhausts in the ceiling, carrying out contaminants without mixing them into the room air.

Waiting rooms and atriums are very good applications for using this kind of air delivery. DV is also common in auditoriums.

Unique diffusor design allows them to be incorporated into building structure at lower elevations in respective rooms.

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Advantage of Displacement Ventilation for Infection Prevention and Energy Management

Infection Prevention
- Room temps may seem warmer due to delivery temp higher.
- Rising temp creates upward buoyance to lift particles
- When infectious particle above breathing zone safe?

Energy Management
- Air delivered to room for comfort already >60F
- Lower energy costs
- Decrease air exchange for room by using 6 ft instead of 8 ft for calculation

Disadvantage: Difficult to find space in a patient room to deliver air low
Heat Wheels can Reclaim Energy

A diagram of a rotary heat exchanger, or "heat wheel" (From Uptime Technology BV).

Aware of air flow direction (clean to dirty) and need to clean the wheel

How is it maintained?

Causes of Ventilation Deficiencies

- Plugged Filters
- Plugged Temperature Control Coils
- Duct Leakage
- Dust on Fan Blades
- Fan Belt Slippage
- Uncalibrated Control Equipment
  - Digital Controls
  - Pneumatic Controls
  - Plugged sensors

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HVAC – Chilled Water System

Punching the tubes and cleaning heat exchanger allows efficient energy transfer

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Deep Cleaning Process
Recover Coil Heat Transfer Performance

Result:
More air and cooler air

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Dirty pre filters and final filters

**DIRTY**

**CLEAN**

Impact of Air Flow On Room Particle Contamination

<table>
<thead>
<tr>
<th>ACH</th>
<th>90% Efficiency</th>
<th>99% Efficiency</th>
<th>99.9% Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>69</td>
<td>138</td>
<td>207</td>
</tr>
<tr>
<td>4</td>
<td>35</td>
<td>69</td>
<td>104</td>
</tr>
<tr>
<td>6</td>
<td>23</td>
<td>46</td>
<td>69</td>
</tr>
<tr>
<td>8</td>
<td>17</td>
<td>35</td>
<td>52</td>
</tr>
<tr>
<td>10</td>
<td>14</td>
<td>29</td>
<td>41</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>23</td>
<td>35</td>
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<td>15</td>
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<td>16</td>
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<tr>
<td>20</td>
<td>7</td>
<td>14</td>
<td>21</td>
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<tr>
<td>50</td>
<td>3</td>
<td>6</td>
<td>5</td>
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</table>

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Filter Engineering Solutions
Impact of Innovative Filter Technologies

Synthetic electrostatic fibers may degrade quickly

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Reality Check!
While the filter bank of bag filters looks good?

You might not be able to see it all.....
When filters oscillate they wear & tear.

Removal Efficiency In-Situ by Particle Size and Resistance to Flow

Before

Direction of Airflow

After

Particle Counter

Before filter
12176 p/ft^3

After filter
40 p/ft^3
>99% reduction

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Joint Commission Findings
Top 11 out of 20 are Building Related

<table>
<thead>
<tr>
<th>Top 20 Rank</th>
<th>Standard</th>
<th>1st Half 2012 RFIs</th>
<th>2011 RFIs</th>
<th>Subject</th>
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</thead>
<tbody>
<tr>
<td>2</td>
<td>LS.02.01.20</td>
<td>52%</td>
<td>56%</td>
<td>Means of Egress</td>
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<tr>
<td>3</td>
<td>LS.02.01.10</td>
<td>47%</td>
<td>52%</td>
<td>General LSC Requirements</td>
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<tr>
<td>4</td>
<td>EC.02.03.05</td>
<td>40%</td>
<td>40%</td>
<td>Features of Fire Safety</td>
</tr>
<tr>
<td>7</td>
<td>LS.02.01.30</td>
<td>36%</td>
<td>45%</td>
<td>Life Safety Protection</td>
</tr>
<tr>
<td>8</td>
<td>LS.02.01.35</td>
<td>35%</td>
<td>31%</td>
<td>Fire Suppression Systems</td>
</tr>
<tr>
<td>9</td>
<td>EC.02.06.01</td>
<td>32%</td>
<td>29%</td>
<td>Built Environment</td>
</tr>
<tr>
<td>10</td>
<td>EC.02.02.01</td>
<td>29%</td>
<td>23%</td>
<td>Hazardous Materials &amp; Waste</td>
</tr>
<tr>
<td>11</td>
<td>EC.02.05.01</td>
<td>28%</td>
<td>25%</td>
<td>Utility Systems (Ventilation)</td>
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<tr>
<td>16</td>
<td>EC.02.05.09</td>
<td>24%</td>
<td>22%</td>
<td>Medical Gases</td>
</tr>
<tr>
<td>17</td>
<td>EC.02.05.07</td>
<td>23%</td>
<td>26%</td>
<td>Emergency Power</td>
</tr>
<tr>
<td>20</td>
<td>EC.02.03.01</td>
<td>19%</td>
<td>21%</td>
<td>Fire Safety</td>
</tr>
</tbody>
</table>

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Room 206

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Patient Mock-up Room Leakage Application Overview

Why should we seal rooms anyway??

Ventilation:
Mock Up Testing

Blower doors allow for leakage testing by applying pressure and using smoke stick to find leaks for sealing

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Duct Blaster evaluation of All room

Depressurize room and record air flow volume to determine room leakage. Four All rooms evaluated with average of 22 inch²/100ft²; two sealed rooms 3.1 in²/100ft².

AIR TIGHT HOUSES STANDARD AT 2.5 inch² /100ft²
Leakage defined as # cfm @ x pressure Pascal¹’s or WC

Finding leakage points in rooms helps assure consistent pressure management

Design for airborne infection isolation rooms the size at UMMC when sealed will move 84 cfm air at 10 Pascal¹’s pressure to achieve 2.5 in²/100ft² surface area. Leakage at about 0.1 cfm/ft².

A sealed room has two advantages:
- controlled sound movement
- ventilation control for infectious disease management

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Room Seal Necessary for Special Ventilation Management

- Cracks can result in room air leakage.
- Supply air volume differential allows for airflow direction control.
- Low pressure differential can result in airflow reversal.
- Substantial room pressure design should provide a sealed “vessel”.
- Design criteria are necessary for control.

Case Study- Barrier Management “Leakage”

Total Barrier Management practices increase build integrity beyond UL systems with additional secondary attributes

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*Loss of corridor space and 2 x Nurse Alcoves

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Wall Penetrations Can Circumvent Ventilation Parameters

Plugging holes will help maintain pressure goals

TESTING PENETRATIONS WITH BLOWER DOOR PRESSURIZATION

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Application Test Series – Complete Overview

<table>
<thead>
<tr>
<th>Blower Test #</th>
<th>Test Application</th>
<th>Status</th>
<th>CFM Per Application</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>HVAC</td>
<td>Open</td>
<td>7500</td>
</tr>
<tr>
<td>2</td>
<td>HVAC</td>
<td>Sealed</td>
<td>99.95</td>
</tr>
<tr>
<td>3</td>
<td>BOV</td>
<td>Open</td>
<td>99.95</td>
</tr>
<tr>
<td>4</td>
<td>BOV</td>
<td>Sealed</td>
<td>99.95</td>
</tr>
<tr>
<td>5</td>
<td>Plumbing</td>
<td>Open</td>
<td>816.3</td>
</tr>
<tr>
<td>6</td>
<td>Plumbing</td>
<td>Sealed</td>
<td>816.3</td>
</tr>
<tr>
<td>7</td>
<td>Low Voltage</td>
<td>Open</td>
<td>98.85</td>
</tr>
<tr>
<td>8</td>
<td>Low Voltage</td>
<td>Sealed</td>
<td>98.85</td>
</tr>
<tr>
<td>9</td>
<td>Electrical Boxes</td>
<td>Open</td>
<td>40.63</td>
</tr>
<tr>
<td>10</td>
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</tr>
<tr>
<td>11</td>
<td>Mechanical</td>
<td>Open</td>
<td>40.63</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
<td>Sealed</td>
<td>40.63</td>
</tr>
</tbody>
</table>

Case Study- Barrier Management

LIFE SAFETY/FIRE

- The most common requirement for control is the UL or life safety considerations as they pertain to fire and smoke control. Hospital corridors and other potential fire hazard need to be sealed.

- Fire management in healthcare has provided safety to millions of healthcare building occupants resulting in enormous strides in fire management through regulation. NFPA, Life safety 99 and 101.

- What additional benefits can be realized?

Total Barrier Management practices increase build integrity with life safety and fire secondary attributes

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Case Study- Barrier Management

- Additional benefits of a sealed room include sound mitigation. It is common acoustical knowledge that sound transmission can be partially mitigated by impeding air movement. This practice occurs where airport noise is managed with sealed houses to minimize sound wave infiltration. HIPPA requires privacy from hearing patient conditions.

- Explain some of the physics of sound transmission

Total Barrier Management practices increase build integrity and sound migration secondary attributes

Case Study- Barrier Management

- Building design in healthcare includes inoperable windows to prevent infiltration of uncontrolled air. Comfort factors are essential to convalescence therefore to maintain temperature between 68 and 72 can be difficult without controlled ventilation.

- Leakage reduction will require less heating and cooling??

- Does a sealed room/building provide ventilation energy efficiency?

- Provide some energy statistics??

Total Barrier Management practices increase build integrity and energy & comfort secondary attributes

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Case Study- Barrier Management

- Control of aerosol important principal for airborne infectious agents causing tuberculosis or aspergillosis depends on airflow control. Aerosol management due to patient derived symptoms needs masking and special room ventilation. Aerosol control is dependent on airflow direction intensity.

- Excess room leakage will diminish pressure management design. A sealed room will help provide consistent direction for prevention of occupational exposures to droplet nuclei containing Mycobacterium tuberculosis or chicken pox.

Total Barrier Management practices increase build integrity and infection prevention secondary attributes.

Infection Prevention and Ventilation

- Air volumes must be maintained to assure cleaning the air of contaminants.
- Impediments include: plugged equipment that needs cleaning or change out of filters.
- Aspiring to have good air quality requires routine maintenance to assure AC/hr, filtration and pressure.

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Questions & Answers
strei001@umn.edu

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EVIDENCE VS. TRADITION: EXAMINING THE EVIDENCE OF BATHING TO
REDUCE HAI’S
Kathleen Vollman, Advanced Nursing LLC
Sponsored by Sage Products (www.sageproducts.com)

September 28  (Free British Teledass ... Broadcast live from the 2015 IPS conference)
WHAT DID THE ROMANS EVER DO FOR US?
Carole Fry, Healthcare Infection Society

September 29  (Free British Teledass ... Broadcast live from the 2015 IPS conference)
FAECAL TRANSPLANT TO TREAT CLOSTRIDIUM DIFFICILE DISEASE
Dr. Jonathan Sutton, Betsi Cadwaladr University Health Board, Wales

September 30  (Free British Teledass ... Broadcast live from the 2015 IPS conference)
THE EMERGENCE OF MERS: FROM ANIMAL TO HUMAN TO HUMAN
Professor Ziad Memish, Prince Mohammed Bin Abdulaziz Hospital, Saudi Arabia

October 14  (FREE WHO Teleclass - Europe)
THE USE OF SOCIAL MEDIA IN SUPPORT OF GLOBAL INFECTION
PREVENTION AND CONTROL

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