HVAC IN HEALTHCARE

UK PRACTICE COMPARED TO NORTH AMERICA

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ENVIRONMENTAL DESIGN CONSULTANTS, CHORLEY, LANCASHIRE

HVAC ISSUES

• IAQ AND IEQ
• INFECTION CONTROL
• ENERGY USE
• RESILIENCE
• CAPITAL COST
• RUNNING COSTS
• MAINTAINABILITY
• SUSTAINABILITY
• FIRE AND SMOKE CONTROL

UK STANDARDS

• HTM 03 COMPREHENSIVE AND THOROUGH
• DETAILED GUIDANCE
• ALLOWS DESIGN FLEXIBILITY
• DEFINES STANDARDS CLEARLY

Dept of Health HTMs
REASONS FOR VENTILATION

- **HUMAN HABITATION**
- **ACTIVITIES RELATED** – extraction of odours, aerosols, gases, vapours, fumes and dust – some of which may be toxic, infectious, corrosive, flammable or otherwise hazardous.
- **Dilution and control of airborne pathogenic material**
- **Thermal comfort**
- **Removal of heat generated by equipment**
- **Removal of solar heat gains**
- **Combustion air**
- **‘make up’ air for local exhaust ventilation**

Infection Control

Recent interest in airborne infections (e.g. 6750 new cases of TB reported in 1999 in UK), and costs of dealing with Nosocomial infections (originating from hospital) estimated in excess of £1 billion per annum in UK (100,000 infections each year). Most pathogens affect immuno-compromised patients e.g. C Difficile affects the elderly disproportionately. Clinicians are also a vulnerable group.

**Airborne vs Contact**

- Person to person contact is the most important transmission route - cleaning/hygiene/good practice.
- However, Beggs and others argue that the airborne route may be greater than recognised.
- Major infectious disease such as TB, have stronger evidence on airborne route transmission. Nosocomial (hospital acquired) infection is relatively unclear.
- A recent systematic review found that out of 40 studies, (only 10 of which considered conclusive), there was a link between ventilation and transmission of infection (e.g. measles, TB, influenza, smallpox, chicken pox) (Li et al 2007). They conclude that there is enough data to support used of pressurised isolation rooms, however insufficient data to specify minimum ventilation requirements in hospitals.
### General Filters

<table>
<thead>
<tr>
<th>BS EN 779 grade (Enamnet grade)</th>
<th>% Aeropace</th>
<th>Notes and typical healthcare applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1 (EU1)</td>
<td>&lt;65</td>
<td>Metal-mesh grease filter</td>
</tr>
<tr>
<td>G2 (EU2)</td>
<td>65 to &lt;80</td>
<td>Coarse primary filter</td>
</tr>
<tr>
<td>G3 (EU3)</td>
<td>80 to &lt;90</td>
<td>Primary air intake, Return air, Energy-recovery device protection</td>
</tr>
<tr>
<td>G4 (EU4)</td>
<td>&gt;90</td>
<td>General-purpose tempered air supply</td>
</tr>
</tbody>
</table>

### Fine Filters

<table>
<thead>
<tr>
<th>BS EN 779 grade (Enamnet grade)</th>
<th>% Efficiency</th>
<th>Notes and typical healthcare applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>F5 (EU5)</td>
<td>40 to &lt;60</td>
<td>General-purpose panel/bag filter</td>
</tr>
<tr>
<td>F6 (EU6)</td>
<td>60 to &lt;80</td>
<td>Basic grade filter</td>
</tr>
<tr>
<td>F7 (EU7)</td>
<td>80 to &lt;90</td>
<td>Medium grade bag or pleated paper, Conventional operating theatre supply air</td>
</tr>
<tr>
<td>F8 (EU8)</td>
<td>90 to &lt;95</td>
<td>High grade bag or pleated paper</td>
</tr>
<tr>
<td>F9 (EU9)</td>
<td>&gt;95</td>
<td>Basic HEPA filter – Level 8 clean rooms</td>
</tr>
</tbody>
</table>

### High Efficiency Filters – HEPA

<table>
<thead>
<tr>
<th>BS EN 1822 grade (Enamnet grade)</th>
<th>% Efficiency at most penetrating particle size (MPPS)</th>
<th>Notes and typical healthcare applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1 (EU1)</td>
<td>85</td>
<td>Ultra-clean theatre terminal</td>
</tr>
<tr>
<td>H1 (EU1)</td>
<td>95</td>
<td>Ultra-clean theatre terminal</td>
</tr>
<tr>
<td>H2 (EU2)</td>
<td>95.5</td>
<td>Ultra-clean theatre terminal</td>
</tr>
<tr>
<td>H3 (EU3)</td>
<td>90.95</td>
<td>Ultra-clean theatre terminal</td>
</tr>
<tr>
<td>H4 (EU4)</td>
<td>99.99%</td>
<td>Pharmacy clean suite</td>
</tr>
<tr>
<td>H5 (EU5)</td>
<td>99.99%</td>
<td>Category 3 room extract</td>
</tr>
<tr>
<td>H6 (EU6)</td>
<td>99.99%</td>
<td>Not generally used in healthcare</td>
</tr>
</tbody>
</table>

### Appendix 2 Recommended Air Change Rates

<table>
<thead>
<tr>
<th>Application</th>
<th>Ventilation (AC/hr)</th>
<th>Pressure Drop (Pa)</th>
<th>Supply Flow (cfm)</th>
<th>Noise (dBA)</th>
<th>Temp (°C)</th>
<th>Comments (see further information at <a href="http://www.nuaire.com">www.nuaire.com</a>)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General room</td>
<td>2.5</td>
<td>9</td>
<td>36</td>
<td>30</td>
<td>20-22</td>
<td></td>
</tr>
<tr>
<td>Commercial room (office)</td>
<td>4.0</td>
<td>10</td>
<td>36</td>
<td>30</td>
<td>20-22</td>
<td></td>
</tr>
<tr>
<td>Single room N/C</td>
<td>6.0</td>
<td>15</td>
<td>40</td>
<td>30</td>
<td>20-22</td>
<td></td>
</tr>
<tr>
<td>Clean utility</td>
<td>8.0</td>
<td>20</td>
<td>40</td>
<td>30</td>
<td>20-22</td>
<td></td>
</tr>
<tr>
<td>Duct utility</td>
<td>8.0</td>
<td>25</td>
<td>40</td>
<td>30</td>
<td>20-22</td>
<td></td>
</tr>
<tr>
<td>Ward isolation room</td>
<td>8.0</td>
<td>25</td>
<td>40</td>
<td>30</td>
<td>20-22</td>
<td></td>
</tr>
<tr>
<td>Infectious disease isolation room</td>
<td>10.0</td>
<td>30</td>
<td>40</td>
<td>30</td>
<td>20-22</td>
<td>Infectious isolation rooms may be required</td>
</tr>
<tr>
<td>Needle-particle filter room</td>
<td>10.0</td>
<td>35</td>
<td>40</td>
<td>30</td>
<td>20-22</td>
<td>Needle-particle filter rooms may be required</td>
</tr>
<tr>
<td>Critical care area</td>
<td>10.0</td>
<td>40</td>
<td>40</td>
<td>30</td>
<td>20-22</td>
<td>Isolation rooms may be required</td>
</tr>
<tr>
<td>Nursing room</td>
<td>15.0</td>
<td>45</td>
<td>40</td>
<td>30</td>
<td>20-22</td>
<td>Isolation rooms may be required</td>
</tr>
<tr>
<td>Operating theatre</td>
<td>15.0</td>
<td>50</td>
<td>40</td>
<td>30</td>
<td>20-22</td>
<td>Isolation rooms may be required</td>
</tr>
<tr>
<td>ICU operating theatre</td>
<td>20.0</td>
<td>60</td>
<td>40</td>
<td>30</td>
<td>20-22</td>
<td>Ventilation must be controlled</td>
</tr>
<tr>
<td>Operating theatre - ICU</td>
<td>20.0</td>
<td>60</td>
<td>40</td>
<td>30</td>
<td>20-22</td>
<td>Ventilation must be controlled</td>
</tr>
</tbody>
</table>
UK PRACTICE

- NATURAL VENTILATION ENCOURAGED WHERE RELEVANT
- FULL FRESH AIR MECHANICAL VENTILATION – NO RECIRCULATION
- ENERGY TARGETS SET
- ENVIRONMENTAL TARGETS – NEAT (BREEAM)
- ALL BASED ON EXTENSIVE DEVELOPMENT THROUGH NHS ESTATES AND HEALTHCARE PROFESSIONALS

NORTH AMERICA -PRE 2003

- MAIN SOURCE THE AIA – AMERICAN INSTITUTE OF ARCHITECTS
- 2001 EDITION GUIDELINES FOR DESIGN AND CONSTRUCTION OF HOSPITALS AND HEALTHCARE FACILITIES
- A 5 PAGE CHAPTER IN THE ASHRAE GUIDES

NORTH AMERICA POST 2003

- ASHRAE HOSPITAL DESIGN MANUAL (IN COLLABORATION WITH ASHE)
- 5 YEAR EFFORT, PULLED TOGETHER CURRENT PRACTICE, LITTLE ‘NEW’ MATERIAL.
- TABLE F IN THE GUIDE ‘IS WHAT IT IS ALL ABOUT’. THIS SIMPLY STATES AIR CHANGE RATES, TEMPS, HUMIDITIES ETC
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6/2/08 FRANK MILLS, EDC 22

6/2/08 FRANK MILLS, EDC 23

6/2/08 FRANK MILLS, EDC 24

**EUROPEAN COUNTRIES**

- SEMINAR HELD IN DEC 2006
- 10 COUNTRIES ATTENDED – 10 DIFFERENT STANDARDS
- GERMANY HAS 2 OPPOSING STANDARDS – DIN AND VDI
- ALL DIFFER FROM UK
- MAJOR CONCERNS FROM EACH OVER INFECTION RATES
**INFECTION RATES - PUBLIC PERCEPTION**

- In December 2000, Robert Bezell of NBC News reported ... 'It’s a danger of staggering proportions. Every year 1 in 20 Americans – 8 million people – develop an infection, with 88,000 of them dying. The biggest threat: supergerms – resistant to bacteria.'

**ASHRAE / ASHE IAQ 2004 VENTILATION OF HEALTHCARE BUILDINGS**

- A JOINT CONFERENCE HELD IN TAMPA TO DISCUSS HOSPITAL AIR QUALITY
NIH RESEARCH

- DR FARHAD MEMARZADEH
- CFD DESK BASED STUDIES
- LOOKED AT DIFFERENT AIRFLOW STRATEGIES
- RESULTS USED IN GUIDE
- PRACTICAL RESEARCH NOW STARTED AT GEORGIA TECH, ATLANTA
NHS – HBN4 -ISOLATION ROOMS

Process

- Identification of condition and/or clinical requirements
- Provision of mechanically ventilated room to appropriate strategy
- Infection control procedures by medical staff and visitors
- Use of appropriate PPE

ASHRAE STANDARD 170P

- ISSUES IN DRAFT IN SEPTEMBER 2005
- CONSULTATION ENDED IN NOVEMBER
- ASHRAE MUST REVISE TO TAKE ACCOUNT OF OVER 30,000 COMMENTS
- PLANNED TO PUBLISH IN 2006 BUT FAILED TO DO SO BECAUSE SO MANY ADVERSE COMMENTS. NEW TARGET IS 2009
- WAS BE ISSUED FOR FURTHER CONSULTATION THIS YEAR.
Purpose of an Air quality standard

- VENTILATION SYSTEM DESIGN
- COMFORT
- ASEPSIS
- ODOUR CONTROL
- MEDICAL GASES

OPERATING THEATRES

AMERICANS PROPOSE 3 CLASSES OF SURGERY…
- CLASS A
- CLASS B
- CLASS C
- BUT ONLY 2 MENTIONED IN THEIR DESIGN GUIDE
UK IS LOOKING AT 5 TYPES

LAMINAR AIR FLOW

- STANDARD PROPOSES A STANDARD DESIGN SOLUTION
- PRESCRIPTIVE APPROACH
- LOCATION OF SUPPLIES AND EXTRACTS
- SPECIFIES DIFFUSER TYPES

AMERICAN APPROACH TO SPACE VENTILATION

- TEMPS, HUMIDITY, AIR CHANGE RATES FOR EACH ROOM TYPE
- REIRC PERMITTED IN MOST ROOMS – eg ORs can have 4 fresh air and 16 recirc air changes per hour
- NATVENT not permitted due to pressure requirements, temperature, humidity or airchange rate reqs
- FAN COILS VIRTUALLY OUTLAWED
AIR CLEANERS

- HEPA FILTRATION GENERALLY USED
- UV SYSTEMS NOT MENTIONED
- LOCAL RECIRC HEPAFILTERS NOT MENTIONED – BUT SEEM TO BE RULED OUT BY BAN ON ‘IN ROOM’ UNITS – HOWEVER NEW SWEDISH SYSTEM LOOKS GOOD

FIRE SAFETY

- PART B REVISED IN APRIL 2007 TO COVER HOSPITALS
- HTM 86 WITHDRAWN
- FIRECODE DOC STILL SIGNED OFF BY CHIEF EXECUTIVE
- VENTILATION AND SMOKE FLOWS ARE ISSUES TO CONSIDER.

CANADIAN STANDARD

Public Review Comment Closing Date: May 17, 2008

DRAFT STANDARD

Z317.3 Special Requirements for Heating, Ventilation, and Air Conditioning (HVAC) Systems in Health Care Facilities

Draft new edition March 12, 2008

<table>
<thead>
<tr>
<th>Item</th>
<th>Dimensions</th>
<th>Heat Dissipation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Table</td>
<td>30’ wide x 30’ high x 72” long</td>
<td>None – operating table only operates intermittently</td>
</tr>
<tr>
<td>Surgical Lights (x2)</td>
<td>2” diameter x 1’ hemisphere</td>
<td>150W each</td>
</tr>
<tr>
<td>Surgical Staff</td>
<td>Height assumed as 5’ 9”  Two at the End on either side of the surgery site</td>
<td>100W Each</td>
</tr>
<tr>
<td>Anesthesia Machine</td>
<td>38” x 30” x 48” high</td>
<td>200 W</td>
</tr>
<tr>
<td>Machine</td>
<td>36” x 30” x 36” high</td>
<td>None - represents equipment only</td>
</tr>
<tr>
<td>Mayo Stand</td>
<td>10” x 30”, located 8” above patient level</td>
<td>None</td>
</tr>
<tr>
<td>Back Table</td>
<td>36” x 30” high x 60” long</td>
<td>None</td>
</tr>
<tr>
<td>Monitor and Stand (x2)</td>
<td>Standard: 12” x 24” x 40” high  Monitor: 18” x 18” x 10” high</td>
<td>Monitors dissipate 200W each</td>
</tr>
<tr>
<td>Patient</td>
<td>With drapes, patient covers most of body</td>
<td>Exposed back dissipates 40W (70% of 65W); Surgery site is 1’ x 1’ area with surface temperature = 100°F</td>
</tr>
<tr>
<td>Overhead lights (x6)</td>
<td>6” x 1’</td>
<td>180W each</td>
</tr>
</tbody>
</table>
CONCLUSIONS

• MAJOR DIFFERENCES BETWEEN NORTH AMERICA, EUROPE AND UK.
• FULL FRESH AIR v RECIRC
• NAT VENT OR NOT
• DISPLACEMENT v MIXING/DILUTION
• UK APPEARS TO BE LEADING THE WAY TOWARD EFFICIENT AND ENVIRONMENTALLY COST EFFECTIVE HOSPITALS