HVAC IN HEALTHCARE

UK PRACTICE COMPARED TO NORTH AMERICA

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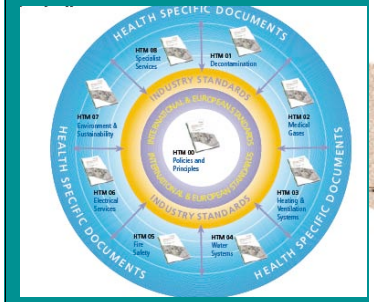
HVAC ISSUES

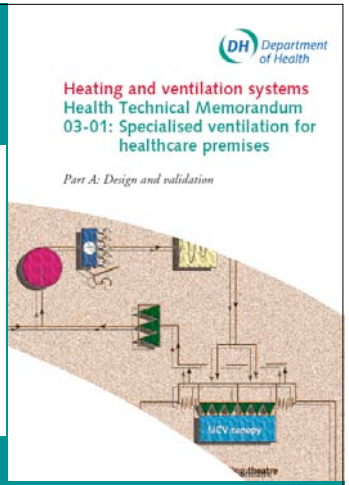
- IAQ AND IEQ
- INFECTION CONTROL
- ENERGY USE
- RESILIENCE
- CAPITAL COST
- RUNNING COSTS
- MAINTAINABILITY
- SUSTAINABILITY
- FIRE AND SMOKE CONTROL

UK STANDARDS

- HTM 03 COMPREHENSIVE AND THOROUGH
- DETAILED GUIDANCE
- ALLOWS DESIGN FLEXIBILTY
- 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

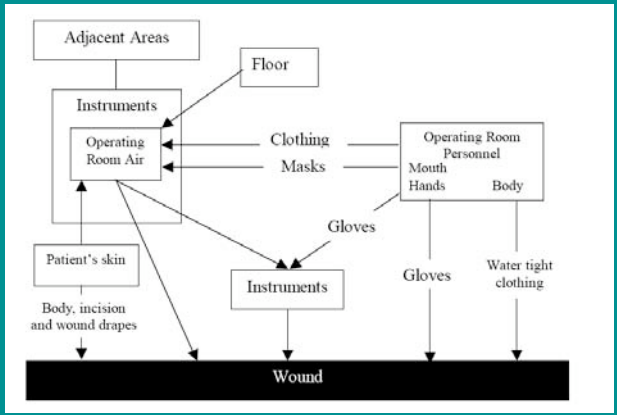
Recent interest in airborne infections (e.g. 6750 new cases of TB reported in 1999 in UK), and costs of dealing with Nosocomial infections (originating from hospital) estimated in excess of £1 billion per annum in UK (100,000 infections each year).

Most pathogens affect immuno-compromised patients e.g. C Difficile affects the elderly disproportionately. Clinicians are also a vulnerable group.

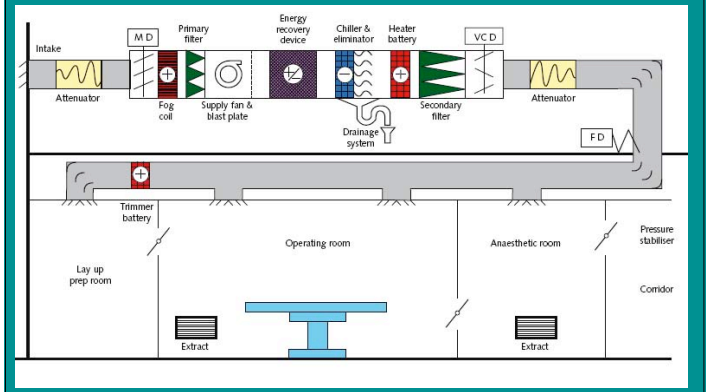
Airborne vs Contact

- 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.

SOURCES AND ROUTES OF INFECTION IN AN OPERATING THEATRE



Operating theatre schematic



GENERAL FILTERS

BS EN 779 grade (Eurovent grade)	% Arrestance	Notes and typical healthcare applications
G1 (EU1)	<65	Metal-mesh grease filter
G2 (EU2)	65 to <80	Coarse primary filter
G3 (EU3)	80 to <90	Primary air intake; Return air; Energy-recovery device protection
G4 (EU4)	>90	General-purpose tempered air supply

FINE FILTERS

BS EN 779 grade (Eurovent grade)	% Efficiency	Notes and typical healthcare applications
F5 (EU5)	40 to <60	General-purpose panel/bag filter
F6 (EU6)	60 to <80	Basic grade bag filter
F7 (EU7)	80 to <90	Medium grade bag or pleated paper Conventional operating theatre supply air
F8 (EU8)	90 to <95	High grade bag or pleated paper
F9 (EU9)	>95	Basic HEPA filter – level 8 clean rooms

HIGH EFFICIENCY FILTERS - HEPA

BS EN 1822 grade (Eurovent grade)	% Efficiency at most penetrating particle size (MPPS)	Notes and typical healthcare applications
H10 (EU10)	85	Ultra-clean theatre terminal
H11 (EU11)	95	
H12 (EU12)	99.5	
H13 (EU13)	99.95	
H14 (EU14)	99.995	Pharmacy aseptic suite Category 3 room extract
U15–U17	–	Not generally used in healthcare

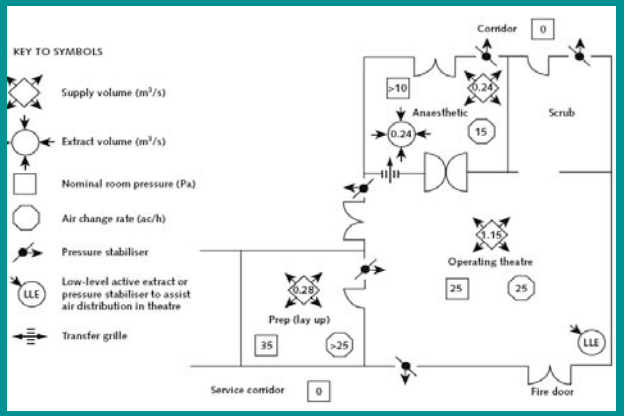
APPENDIX 2 RECOMMENDED AIR CHNAGE RATES

Application	Ventilation	AC/hr	Pressure (Pascals)	Supply filter	Noise (NR)	Temp (°C)	Comments (for further information see Chapter 8)
General ward	S/N	6	–	G4	30	18–28	
Communal ward toilet	E	6	–ve	–	40	–	
Single room	S/E/N	6	0 or –ve	G4	30	18–28	
Single room WC	E	3	–ve	–	40	–	
Clean utility	S	6	+ve	G4	40	18–28	
Dirty utility	E	6	–ve	–	40	–	
Ward isolation room	–	–	–	–	–	–	See Health Building Note 04-01 (Supplement 1)
Infectious diseases isolation room	E	10	–5	G4	30	18–28	Extract filtration may be required
Neutropeanic patient ward	S	10	+10	H12	30	18–28	
Critical care areas	S	10	+10	F7	30	*18–25*	Isolation room may be –ve pressure
Birthing room	S & E	15	–ve	G4	40	*18–25*	Provide clean air-flow path
SCBU	S	6	+ve	F7	30	*18–25*	Isolation room may be –ve pressure
Preparation room (lay-up)	S	>25	35	F7	40	*18–25*	
Preparation room/bay (sterile pack store)	S	10	25	F7	40*	*18–25*	*50 NR if a bay in a UCV theatre
Operating theatre	S	25	25	F7	40	*18–25*	
UCV operating theatre	S	25*	25	H10 or greater	50	*18–25*	*Fresh-air rate; excludes recirculation

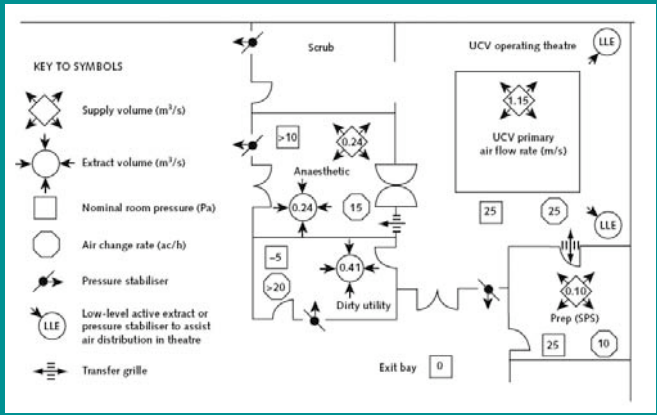
HIERARCHY OF CLEANLINESS

			Air-flow rate for bacterial contaminant dilution	
Class	**Room**	**Nominal pressure (Pa)[a]**	**Flow in or supply (m^3/s)**	**Flow out or extract (m^3/s)**
Sterile	Preparation room		See standard schemes in Appendix 7 for recommended design values	
	(a) lay-up	35		
	(b) sterile pack store	25		
	Operating room	25		
	Scrub bay[b]	25		
Clean	Sterile pack bulk store	+ve	6 AC/h	–
	Anaesthetic room[c]	14[c]	The greater of 15 AC/hr or 0.15	The greater of 15 AC/hr or 0.15
	Scrub room	14	–	0.10
Transitional	Recovery room	3	15 AC/hr[d]	15 AC/hr[d]
	Clean corridor	0	(See note e)	7 AC/hr
	General access corridor	0	(See note e)	7 AC/hr
	Changing rooms	3	7 AC/hr	7 AC/hr
	Plaster room	3	7 AC/hr	7 AC/hr
Dirty	Service corridor	0	–	(See note f)
	Disposal room	–5 or 0	–	0.41 or 0.10

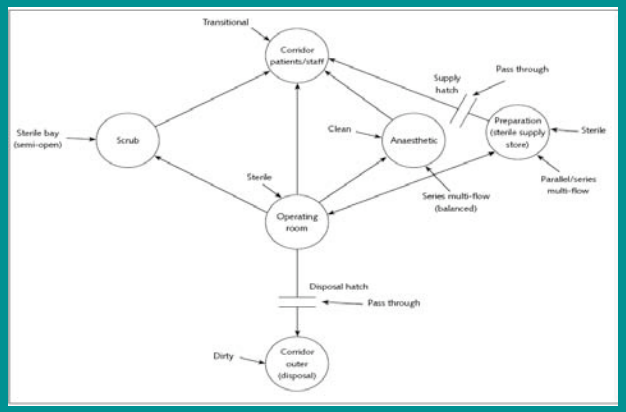
TYPICAL OPERATING THEATRE LAYOUT



UCV THEATRE SUITE



AIRFLOW NETWORK



Appendix 1 – Annual inspection of critical ventilation systems – AHU and plantroom equipment

Definition of terms used on survey form

General condition

End of useful life

This should be clear from the condition of the AHU and its associated services and plant. The main indicators will be:

- extensive internal and/or external corrosion of the AHU casing;
- failure of filter housings to prevent air bypass;
- general corrosion of heater and cooling battery fins, attenuator surfaces etc;
- significant failure to meet minimum standards;
- associated plant services and control elements in a poor condition or not able to fulfil their purpose;
- AHU aged 20 years or more.

Action: Urgent replacement indicated.

Poor

Should be fairly apparent but would include an assessment of the degree of corrosion; cleanliness of coils and batteries; quality of filter mountings and their ability to prevent air bypass; fan and drive train condition; the control system elements' ability to fulfil their function; condition of the access doors and inspection covers. The age of the AHU is generally less important.

Action: Extensive refurbishment or programmed replacement indicated.

Average

Some fault but generally free of significant corrosion, clean internally and conforming to minimum standards.

Action: Faults capable of correction at next maintenance period.

Good

Conforming to the minimum standards, obviously cared for and subject to routine maintenance.

Action: Routine maintenance will preserve standard of the equipment.

UK PRACTICE

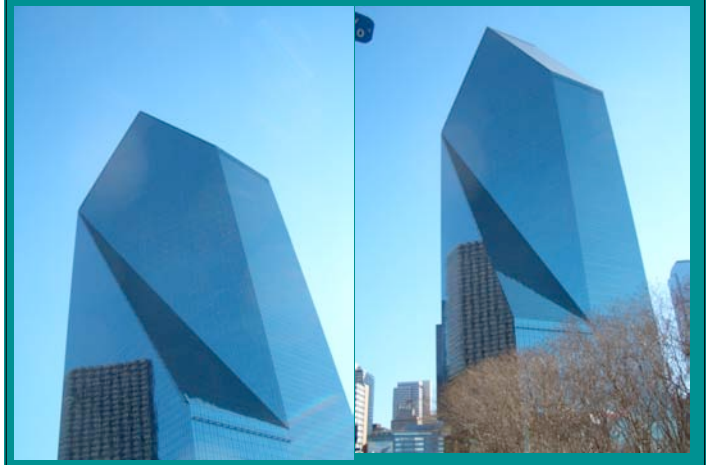
- NATURAL VENTILATION ENCOURAGED WHERE RELEVANT
- FULL FRESH AIR MECHANICAL VENTILATION – NO RECIRCULATION
- ENERGY TARGETS SET
- ENVIRONMENTAL TARGETS – NEAT (BREEAM)
- ALL BASED ON EXTENSIVE DEVELOPMENT THROUGH NHS ESTATES AND HEALTHCARE PROFESSIONALS

NORTH AMERICA -PRE 2003

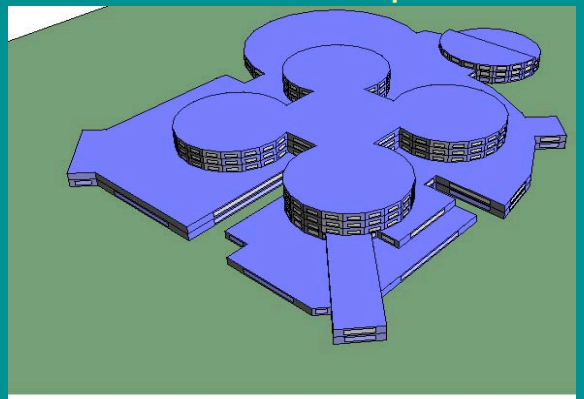
- MAIN SOURCE THE AIA – AMERICAN INSTITUTE OF ARCHITECTS
- 2001 EDITION GUIDELINES FOR DESIGN AND CONSTRUCTION OF HOSPITALS AND HEALTHCARE FACILITIES
- A 5 PAGE CHAPTER IN THE ASHRAE GUIDES

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



Romford hospital



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 VENTIALTION OF HEALTHCARE BUILDINGS

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

STANDARDS ACTIONS

BACKGROUND INFORMATION FOR TPS CHANGES

SPC 170P –Ventilation of Health Care Facilities

1. PURPOSE

The purpose of this standard is to ~~define requirements for~~ ventilation system ~~design, intended~~ to requirements that provide environmental control for comfort, asepsis, and odor in health care facilities.

2. SCOPE

2.1 The requirements in this standard apply to patient care areas and related support areas within health care facilities, including hospitals, nursing facilities, and outpatient facilities.

2.2 This standard ~~is intended to apply~~ applies to new buildings, additions to existing buildings, and ~~those changes~~ alterations to existing buildings that are identified within the this standard.

2.3 This standard considers chemical, physical, and biological airborne contaminants that can affect the delivery of medical care to patients, the convalescence of patients, and the safety of patients, health care workers and visitors.

Table 6.2 Supply Air Outlets

Space Designation (According to Function)	Supply Air Outlet Classification[a]
All Class A, B and C Surgeries[b]	Primary Supply Diffusers Group E, non-aspirating Additional Supply Diffusers, Group E
Protective Environment (PE) Rooms	Group E, non-aspirating
Wound Intensive Care Units (Burn Units)	Group E, non-aspirating
Trauma Rooms (Crisis or Shock)	Group E, non-aspirating
Airborne Infection Isolation Rooms	Group A or Group E
All other spaces	Group A or Group E

Note a: Refer to *2005 ASHRAE Handbook--Fundamentals*, Chapter 33, for definitions related to Outlet Classification and performance (see Bibliography).

Note b: Surgeons may require alternate air distribution systems for some specialized surgeries. Such systems shall be considered acceptable if they meet or exceed the requirements of this standard.

Table 7.1 Design Parameters

Function of Space	Pressure Relationship to Adjacent Areas (n)	Minimum Air Changes of Outdoor Air per Hour	Minimum Total Air Changes per Hour	All Room Air Exhausted Directly to Outdoors (j)	Air Recirculated With in by means of Room Units (a)	Relative Humidity (%)	Design Temperature (f) (°F/°C)
SURGERY AND CRITICAL CARE							
Class B and C Operating room (b),(m),(n) (o)	Positive	4	20	-N/R	No	30-60	68-75/20-24
Operating/surgical cystoscopic rooms (b), (m), (n) (o)	Positive	4	20	N/R	No	30-60	68-75/20-24
Delivery room (Caesarean) (m),(n), (o)	Positive	4	20	-N/R	No	30-60	68-75/20-24
Substerile service area	N/R	2	6	N/R	No	30-60	68-75/21-24
Recovery room	No RequiremenN/R	2	6	-N/R	No	30-60	70-75/21-24
Critical and intensive care	Positive	2	6	-N/R	No	30-60	70-75/21-24
Wound Intensive Care (Burn Unit)	Positive	2	6	N/R	No	40-60	70-75/21-24
Newborn intensive care	Positive	2	6	-N/R	No	30-60	70-75/21-24
Treatment room (p)	No Requiremont N/R	2	6	-N/R	-N/R	30-60	70-75/21-24
Trauma room (crisis or shock) (c)	No Requiremen?nsiti ve	3	15	-N/R	No	30-60	70-75/21-24
Medical Anesthesia gas storage (x)	Negative	-N/R	8	Yes	-N/R	-N/R	-N/R

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

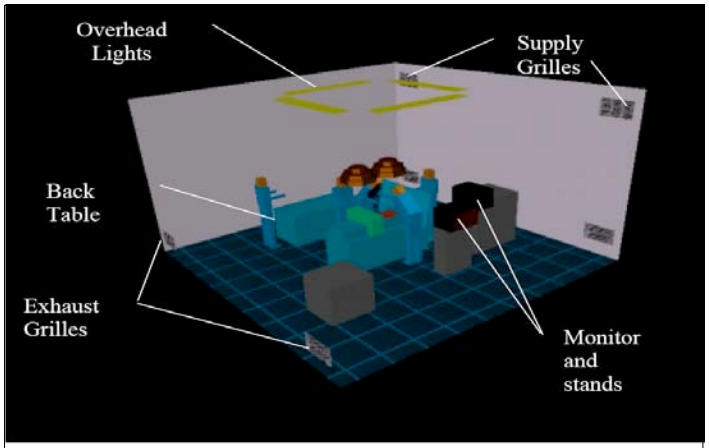
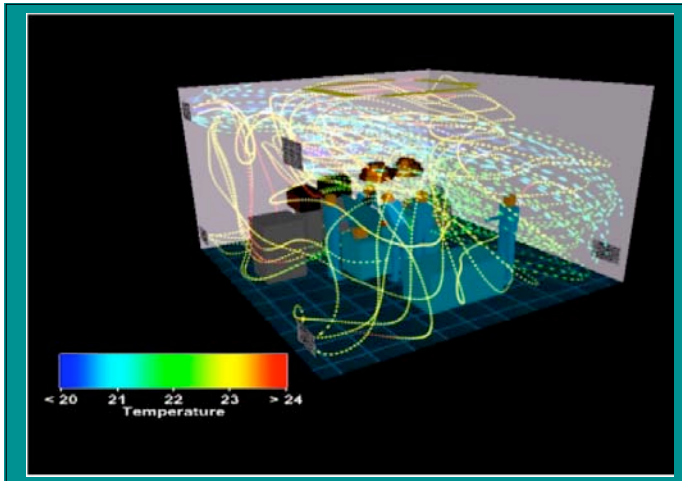


Figure 6. Layout of baseline operating room – Mayo stand view.

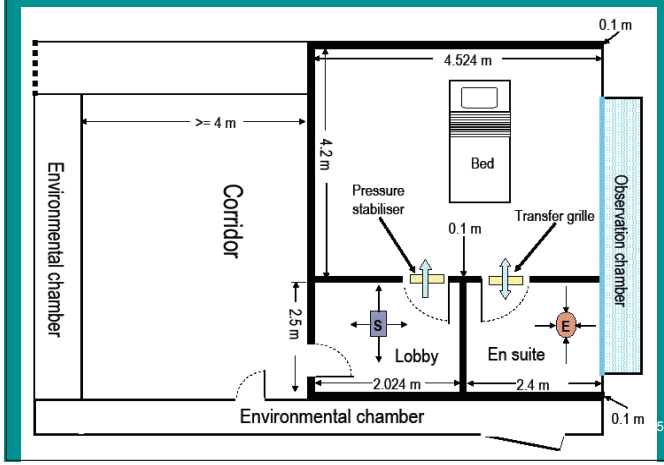


NHS – HBN4 -ISOLATION ROOMS

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

BSRIA TEST LAB MOCK UP



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 COMMMENTS 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 airchanges 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

Z317.2
Special Requirements for Heating, Ventilation, and Air Conditioning (HVAC) Systems in Health Care Facilities

Draft new edition March 12, 2008

Item	Dimensions	Heat Dissipation
Operating Table	30"wide x 30" high x 72" long	None – operating table only operates intermittently
Surgical Lights (x2)	2' diameter x 1' hemisphere	150W each
Surgical Staff	Height assumed as 5' 9" Two of the staff are leaning over surgery site	100W Each
Anesthesia Machine	30" x 30" x 48" high	200 W
Machine1	30" x 30" x 30" high	None- represents blockage only or intermittently operating machinery
Mayo Stand	10" x 30", located 8" above patient level	None
Back Table	30" x 30" high x 60" long	None
Monitor and Stand (x2)	Stand: 12" x 24" x 40" high Monitor: 16" x 18" x 10" high	Monitors dissipate 200 W each
Patient	With drape, patient covers most of table	Exposed head dissipates 46W (70% of 65W); Surgery site is 1' x 1' area with surface temperature = 100°F
Overhead lights (x4)	6' x 1'	180W each

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