SPECIALISED VENTILATION for HOSPITALs

https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

INTRODUCTION

Ventilation / HVAC / MVAC

https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

INTRODUCTION

"Specialised Ventilation"

- Specialized ventilation is provided in patient treatment areas and other locations in a hospital such as operating theaters, critical care areas and isolation units.
  - To protect occupants from health care associated infection or contaminants/fumes
  - To ensure compliance with quality assurance of processed items in pharmacy and sterile services departments

https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

REFERENCE STANDRARDS, CODES OF PRACTICE & GUIDELINES

- HTM Standards
  - HTM 03-01 Specialised Ventilation For Healthcare Premises
  - HTM 04-01 The Control of Legionella, Hygiene, "Safe" Hot Water, Cold Water and Drinking Water Systems
  - HTM 08-01 Acoustics
- CIBSE Guides
  - CIBSE Guides A and B (Information on Ventilation Design)
- ASHRAE Standards
  - HVAC Design Manual for Hospitals and Clinics (2nd Edition)
  - ANSI/ASHRAE/ASHE Standard 170: Ventilation of Health Care Facilities
- Other References
  - Guidelines for Healthcare Engineering Systems of Private Hospitals (DH, HK)
  - ICB Infection Control Guidelines, Section 3.1-Ventilation (DH, HK)
  - ISO/BS EN
  - Fresh Water Cooling Towers Scheme Brochure and Code of Practice for Fresh Water Cooling Towers: Parts 1, 2 & 3 (EMSD, HK)
  - ……..

Objectives of Specialised Ventilation

- Prevention of the spread of airborne infectious disease
- Prevention or control of healthcare-associated infection
- Dilution and removal of contaminants and fumes where used

- Human habitation (minimum fresh-air requirement)
- Facilitating activities of the department (extraction of odours, aerosols, gases, vapours, fumes and dust which may be toxic, infectious, corrosive, flammable, or otherwise hazardous)
- Dilution and control of airborne pathogenic materials

- Thermal comfort
- Removal of heat generated by equipment
- Reduction of the effects of solar heat gains
- Reduction of excessive moisture levels to prevent condensation
- Combustion requirements for fuel burning appliances
- “Make-up supply air” where local exhaust ventilation installed

SPECIALISED VENTILATION SYSTEM FOR HOSPITALS

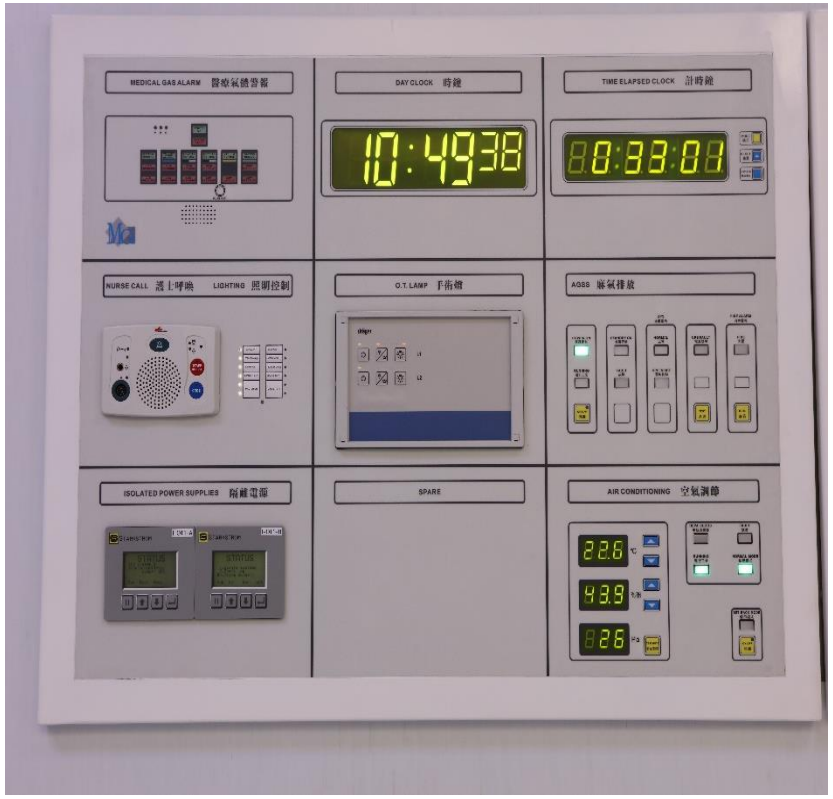
- Design Criteria and Principles
  - Supply Air Requirements
  - Dilution of Airborne Bacterial Contaminants
  - Control of Air Movement
  - Temperature and Humidity Control
  - Removal and Dilution of Waste Anaesthetic Gases
  - Differential Pressures
  - Air Purity

> Adequate air supply
> Air movement : from clean to less clean areas

https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

SYSTEM DESCRIPTION AND PLANTS / EQUIPMENT

- Ventilation, HVAC / MVAC Systems shall contain the following plants / equipment:
  - Water Distribution System
    - Chillers, Pumps, Cooling Towers (for water-cooled system), Chilled Water Pipework
  - Air Distribution System
    - AHUs, FCUs, Air Ductwork, Air Outlets, Filters
    - Laminar Flow Ceiling, Pressure Stabilisers



https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

SYSTEM DESCRIPTION AND PLANTS / EQUIPMENT

Air distribution by Air Handling Units through air ductwork and air outlets/inlets (grilles)

- Supply Air Ducts
- Return Air Ducts
- Exhaust Air Ducts
- Fresh Air Ducts
- Transfer Air Ducts

Specialised Ventilation Requirements (HTM 03-01)

Appendix 2 – Recommended air-change rates

Application	Ventilation	AC/hr	Pressure (Pascals)	Supply filter	Noise (NR)	Temp (°C)	Comments (for further information see Chapter 6)
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
Anaesthetic room	S & E	15	>10	F7	40	*18–25*	Provide clean air-flow path
Theatre sluice/dirty utility	E	>20	–5	–	40	–	
Recovery room	S & E	15	0	F7	35	*18–25*	Provide clean air-flow path
Catheterisation room	S	15	+ve	F7	40	*18–22*	
Endoscopy room	S	15	+ve	F7	40	*18–25*	
Endoscopy cleaning	E	>10	–ve	–	40	–	
Day-case theatre	S	15	+ve	F7	40	*18–25*	
Treatment room	S	10	+ve	F7	35	*18–25*	
Pharmacy aseptic suite	S	20	#	H14	–	*18–22*	# See EGGMP (Orange guide) [a]
Category 3 or 4 containment room	#	>20	#	H14*	–	*18–22*	# See ACDP guide; *Filter in extract
Post-mortem room	S & E	S = 10 E = 12	–ve	G4	35	**18–22**	Provide clean air-flow path
Specimen store	E	–	–ve	–	–	–	Fan accessible from outside of store

Notes: **18–22**°C indicates the range over which the temperature may float.
18–22°C indicates the range over which the temperature should be capable of being controlled.
S = suppy
E = extract
N = natural ventilation
a – European guidelines on good manufacturing practice published by the Medicines and Healthcare products Regulatory Agency (MHRA)

Air Change Rates
Air Pressures

https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

VENTILATION SYSTEM FOR HOSPITALS (HTM 03-01)

Appendix 3 – 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

Notes:

a. Nominal room pressures are given to facilitate setting up of pressure-relief dampers, the calculation process, and the sizing of transfer devices. In practice, the resultant pressures are not critical, provided the desired air-flow rates and movement are achieved.

b. An open or semi-open bay is considered to be part of the operating room; provided air movement is satisfactory, no specific extract is required. However, if the layout means that air movement is poor, a local extract may be required to control local condensation on the building surfaces, which can result in mould growth.

c. For design purposes, anaesthetic should be assumed to be at 14 Pa. When commissioning, 10 Pa is considered suitable.

d. 15 AC/hr is considered necessary for the control of anaesthetic gas pollution.

e. Supply air-flow rate necessary to make up 7 AC/hr after taking into account secondary air from cleaner areas.

f. No dilution requirement. Temperature control requirements only.

Air Movement :
from clean to less clean areas

https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

VENTILATION SYSTEM FOR HOSPITALS (HTM 03-01)

Appendix 4 – Leakage flows in m^3/s through closed door gaps

Type	Pressure difference (Pa)						
	5	10	15	20	25	30	40
Single door	0.03	0.05	0.06	0.06	0.07	0.07	0.08
Double door	0.04	0.08	0.10	0.11	0.12	0.13	0.14
High permanent length of 3 mm gap	0.004	0.008	0.010	0.011	0.012	0.012	0.013

Designers' notes:

The door gaps assumed are 4 mm along the bottom, 3 mm at the top and sides, and 2 mm between double leaves.

If doors are fitted with cold smoke seals, these will significantly reduce the door leakage rate when new and undamaged. It is therefore recommended that provision for the design leakage be factored into the size of the appropriate transfer grille or pressure stabiliser. Failure to do this will result in air-gap whistles and doors being held partially open by air pressure.

Factory-assembled door-sets with a steel frame and pre-hung leaves are becoming common. There is effectively no leakage across these doors when closed. Therefore, when this type of door assembly is fitted, the door leakage can be ignored and the design air flow into the room reduced accordingly. The design air flow would then become that required either (i) for open door protection (Appendix 5), or (ii) to achieve the specified air-change rate – whichever is the greater.

VENTILATION SYSTEM FOR HOSPITALS (HTM 03-01)

Appendix 5 – Recommended air-flow rates in m^3/s through a doorway between rooms of different cleanliness to control cross-contamination

Room class		Dirty	Transitional	Clean	Sterile
Sterile	Hatch	0.3	0.24	0.18	
	Single door	0.47	0.39	0.28	0 or 0.28[a]
	Double door	0.95	0.75	0.57	0 or 0.57[a]
Clean	Single door	0.39	0.28	0 or 0.28[a]	
	Double door	0.75	0.57	0 or 0.57[a]	
Transitional	Single door	0.28	0 or 0.28[a]		
	Double door	0.57	0 or 0.57[a]		
Dirty	Single door	0	Open single door = 0.80 m × 2.01 m high		
	Double door	0	Open double door = 1.80 m × 2.01 m high		

Designers' notes:

The degree of protection required at an open doorway between rooms is dependent on the degree of difference in cleanliness between them.

Flow rate required between rooms within the same class tends to zero as class reduces.

a. If two rooms are of equal cleanliness, no flow is required (in practice there will be an interchange in either direction) and the design of the air movement will assume zero air flow. In certain cases, however, interchange is not permitted, and a protection air flow of 0.28 is assumed in the design – for example in the case of a preparation room used as a "lay up"

https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

VENTILATION SYSTEM FOR HOSPITALS (HTM 03-01)

Appendix 6 – Typical approximate pressures in an operating suite when a given door is open

		Typical approximate effect on other rooms	
Door open between	**Typical approximate resultant pressure in these rooms (Pa)**	**Room**	**Pressure (Pa)**
Operating room and corridor or Scrub bay and corridor	0	Anaesthetic Preparation – lay-up Disposal Preparation – sterile pack store	0 12 –6 5
Operating room and anaesthetic room (or other series room with double doors)	17	Preparation – lay-up Disposal Preparation – sterile pack store	26 –9 22
Operating room and disposal room or Operating room and preparation room	25	No change	
Anaesthetic room and corridor (or other series room with double doors)	0	Preparation – lay-up Disposal Operating room Preparation – sterile pack store	30 –6 20 25
Preparation room and corridor or Disposal room and corridor	0	No change	
Disposal room and outer corridor	0	No change	

Notes:

The room differential pressure protects against reverse flows when the door is closed.

The flow of air through a doorway protects against reverse air flow when the door is open.

Pressure stabilisers control flow and ensure a known air-flow path between rooms when doors are closed, and also reduce back-flow between rooms when doors to other rooms are open

https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

SYSTEM DESCRIPTION AND PLANTS / EQUIPMENT

- Filters
  - Particulate Air Filters are Divided into Four Categories:
    - General Ventilation Filters G1 to G4
    - Fine Filters F5 to F9
    - HEPA Filters H10 to H14
    - Ultra-low Particulate Air Filters (ULPA) U15 to U17

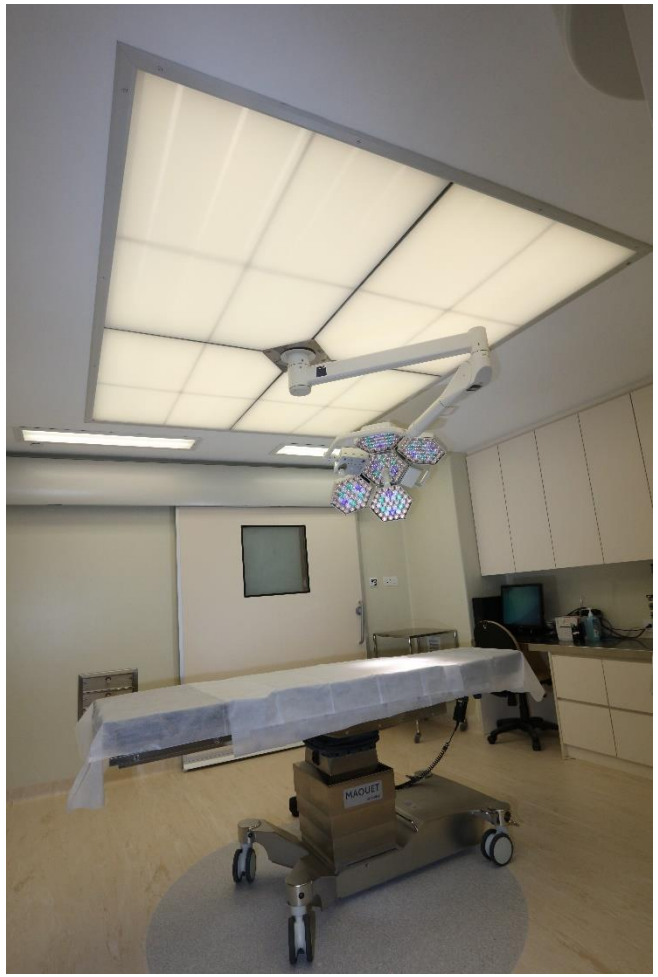
(HTM 03-01)

Table 5 High efficiency (HEPA) filters

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

SYSTEM DESCRIPTION AND PLANTS / EQUIPMENT

- Laminar Flow Ceiling
  - To provide laminar down flow ventilation
  - To perform the following functions against air borne infection:
    - To dilute anaesthetic gas and bacteria carrying air within the OT room
    - To provide a positive pressure zone preventing the ingress of adjacent less clean air into the OT clean zone
    - To perform as a clean laminar air shield over the patient as a clean laminar air shield over the patient and the surgical team, carrying the particles away from the patient and surgeons
    - To provide a comfortable and reliable environment for the surgical team and the patient

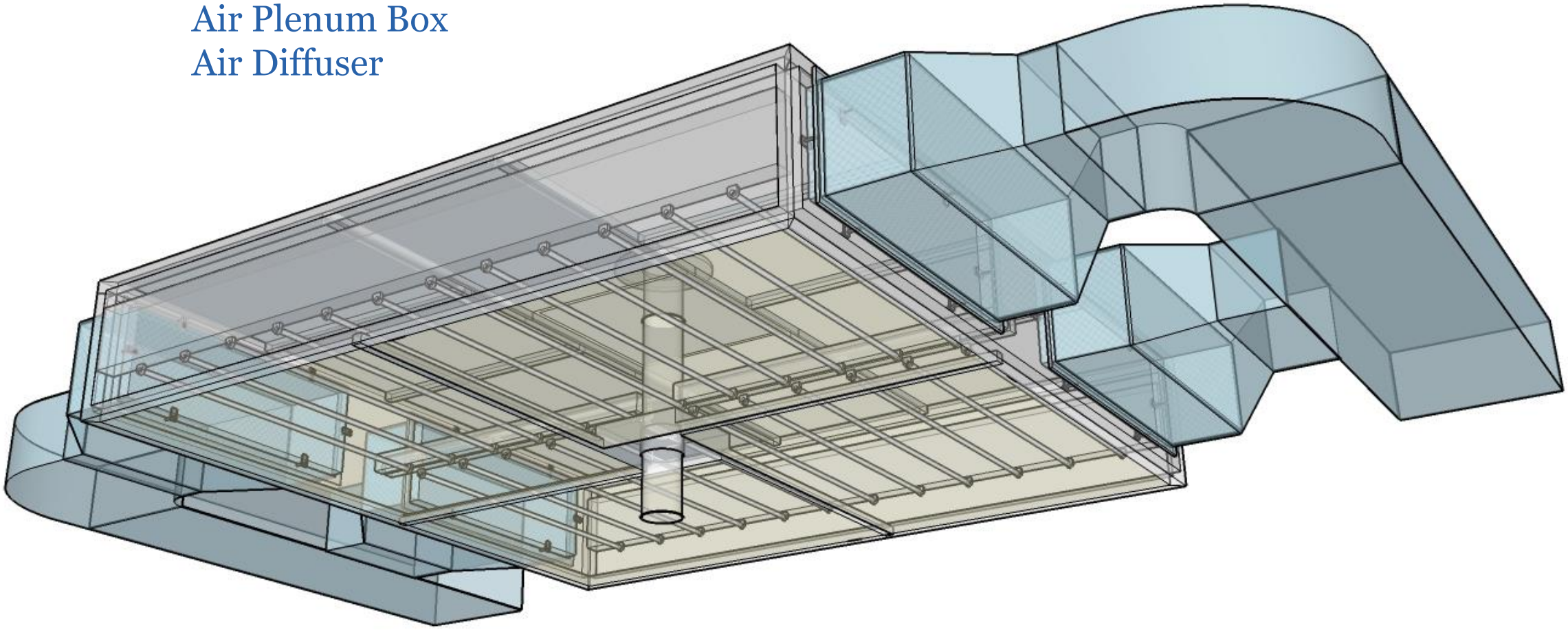


https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

Laminar Air Flow Ceiling

Consisting of:

- Filter Chamber
- Air Plenum Box
- Air Diffuser



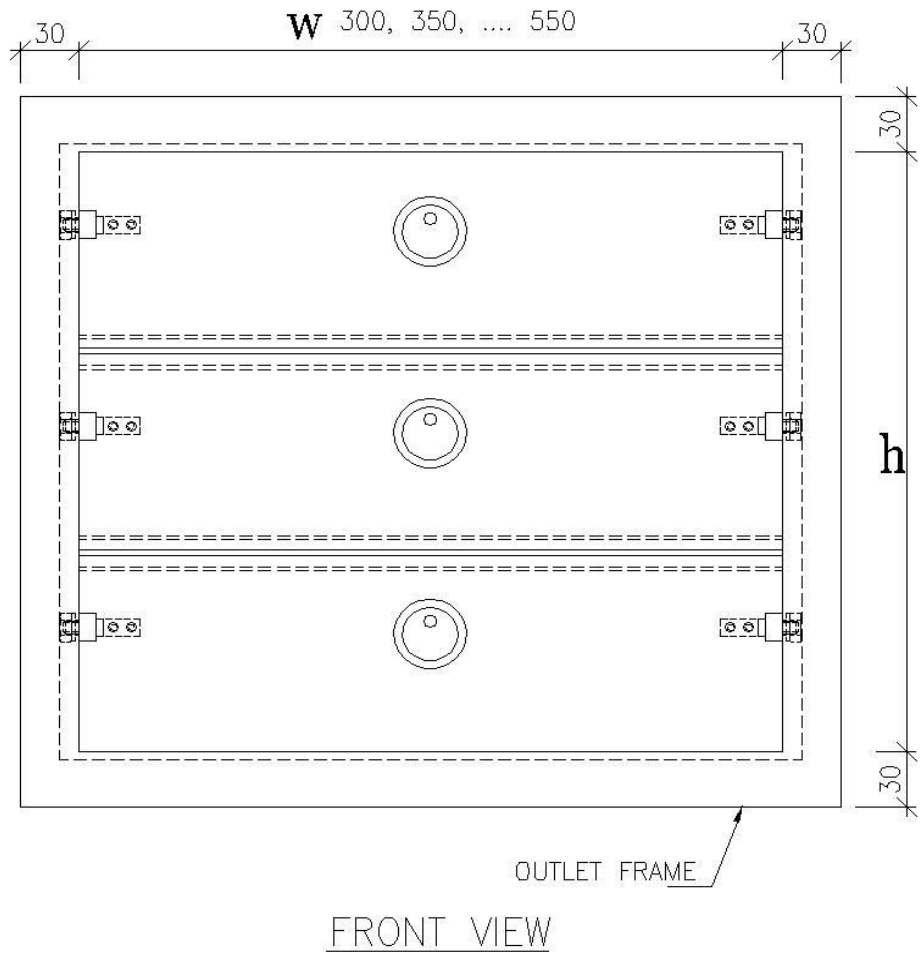
https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

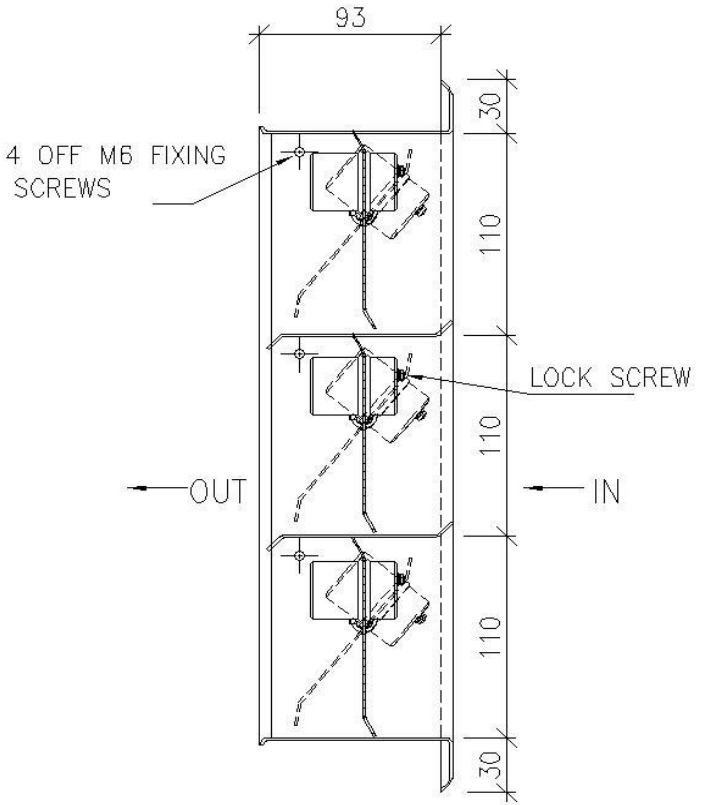
https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

SYSTEM DESCRIPTION AND PLANTS / EQUIPMENT

- Pressure Stabilizers
  - Adjustable to hold the pressure constant over a wide range of flow rates
  - For accurate room-pressure control or rapid shut-off on pressure fall
  - Virtually silent in operation, adjustable on site, maintenance-free, NOT be used in external walls or pressure difference LESS than 5 Pa

https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf





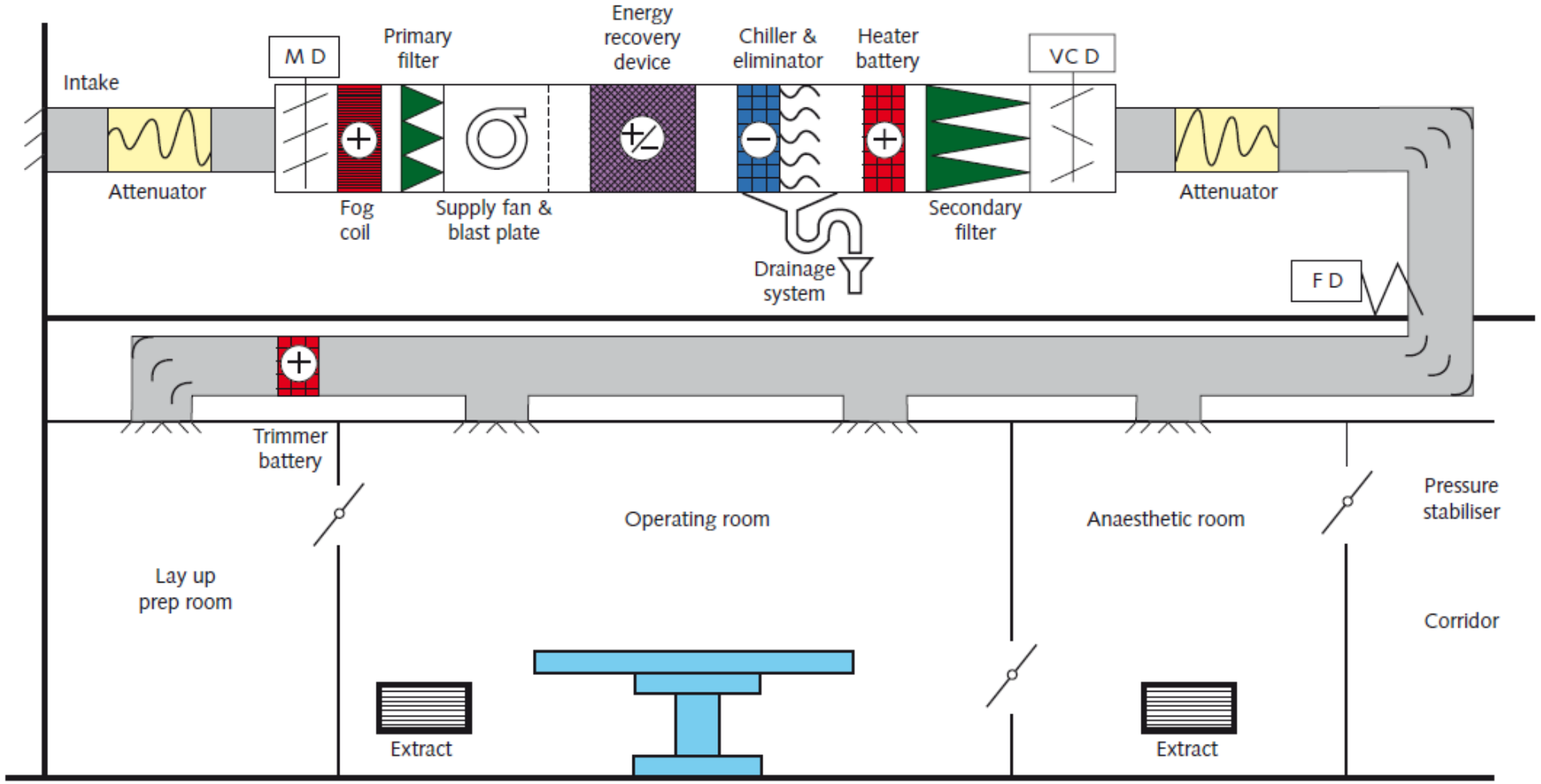
Pressure Stabiliser

Examples / Case Studies

- Ventilation for Operation Theatre Installation

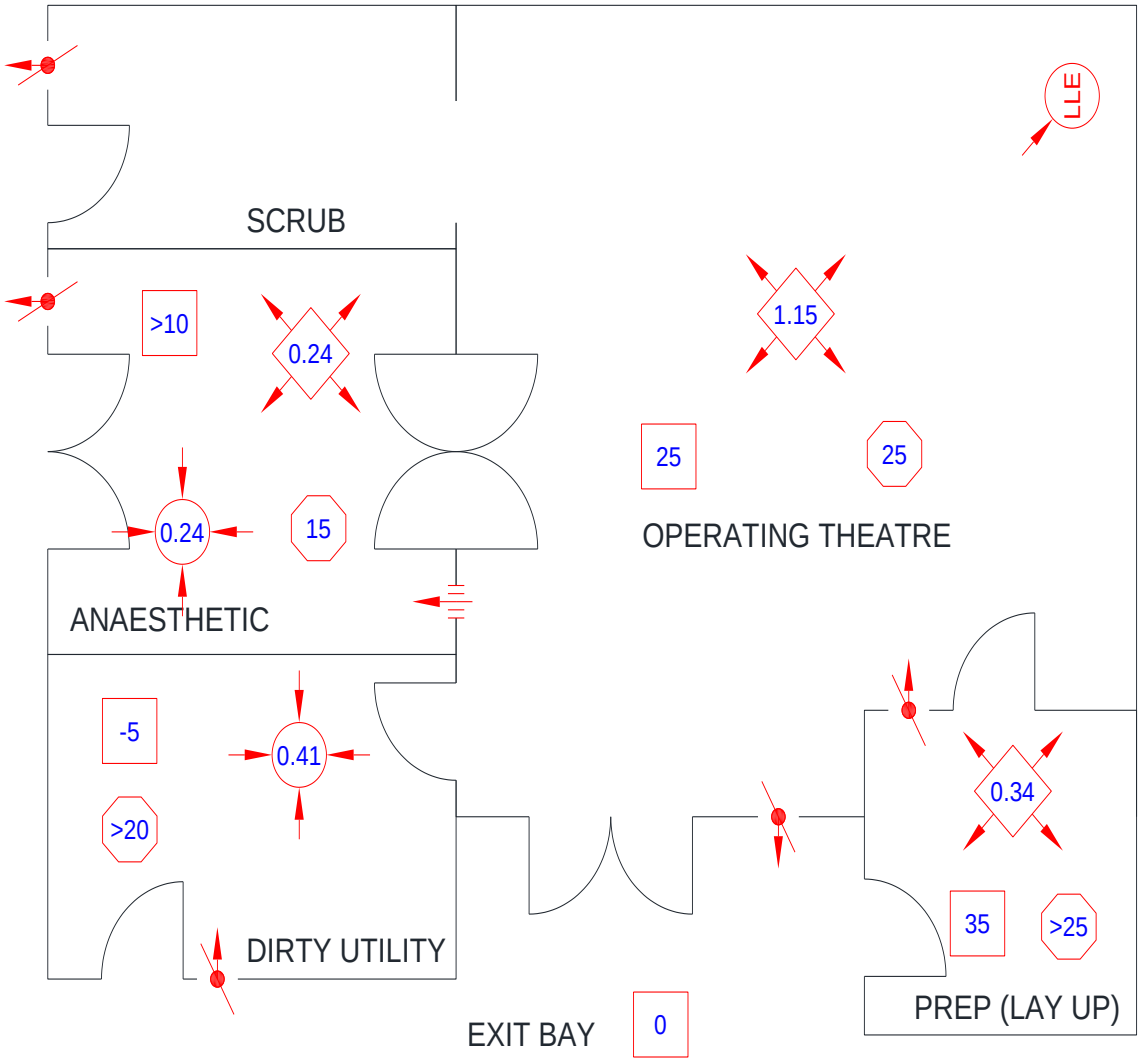
Ventilation Plant & Equipment

Figure 1 Example of a typical operating theatre ventilation system
(HTM 03-01)



https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

Examples / Case Studies



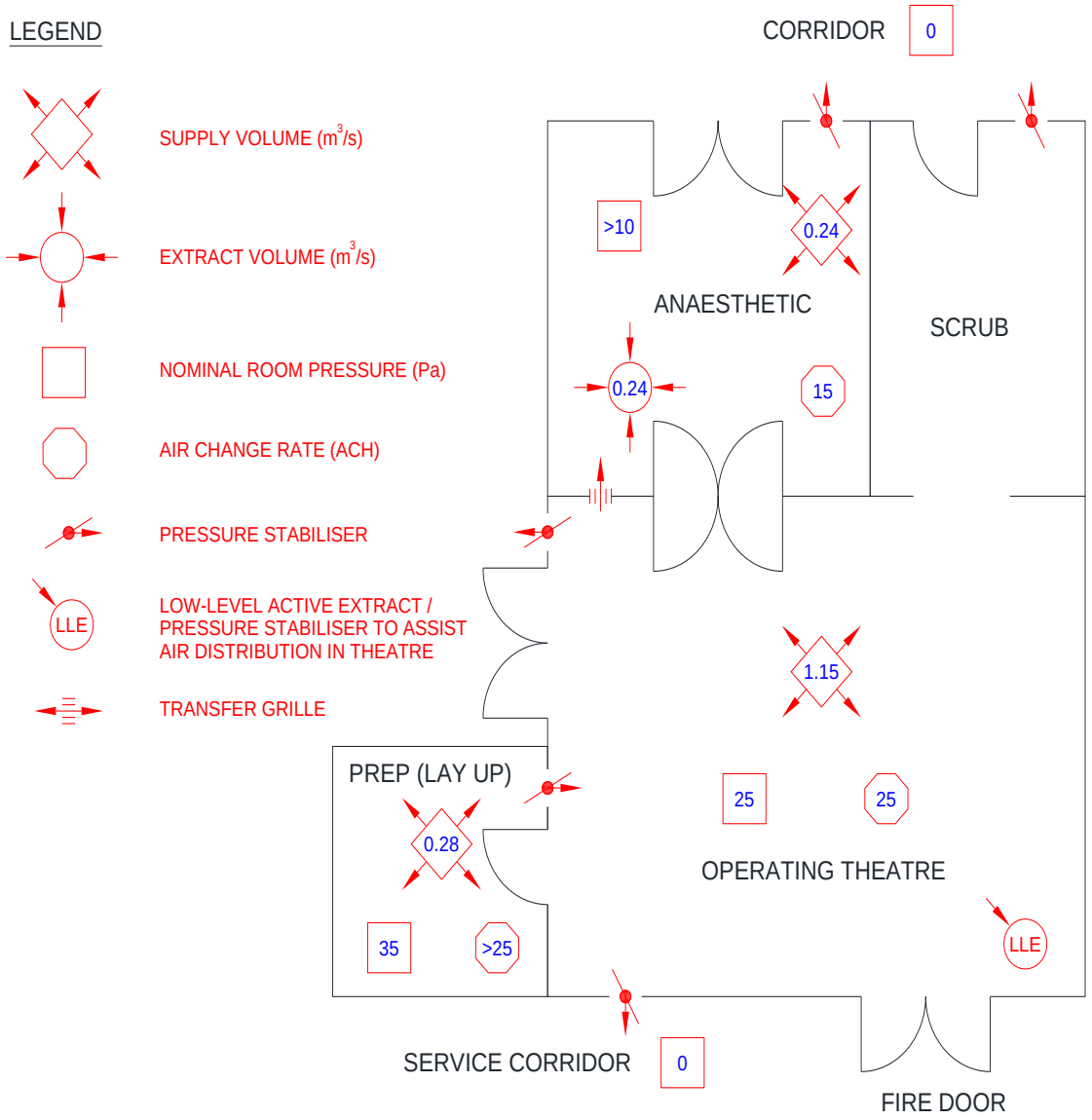
TYPICAL CONVENTIONAL THEATRE (EXAMPLE 1) (HTM 03-01)

LEGEND

- SUPPLY VOLUME (m^3/s)
- EXTRACT VOLUME (m^3/s)
- NOMINAL ROOM PRESSURE (Pa)
- AIR CHANGE RATE (ACH)
- PRESSURE STABILISER
- LLE — LOW-LEVEL ACTIVE EXTRACT / PRESSURE STABILISER TO ASSIST AIR DISTRIBUTION IN THEATRE
- TRANSFER GRILLE

> adequate air supply
> air movement :
from clean to less clean areas

Examples / Case Studies



TYPICAL CONVENTIONAL THEATRE (EXAMPLE 2) (HTM 03-01)

> adequate air supply
> air movement :
from clean to less clean areas

Examples / Case Studies

- ACH
  - ACH (Air Changes Per Hour) - refer to recommended air change rate.
- Differential Pressure
  - Transfer grilles - used to limit the pressure difference
  - pressure stabilizers – adjusted to hold the pressure constant over a wide range of flow rates
- Air Filtration
  - To reduce the level of airborne contamination in an air stream
  - Filters
    - Non-combustible
    - Particles of filter media do not detach and carried away by air flow
    - Accessible for replacement
    - Means of visually checking the differential pressure across filters

https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf

OTHER RELATED CONSIDERATIONS

- Energy Saving Consideration
  - Set-back Mode
  - Energy Recovery System
  - Variable Speed Fans
  - Building Energy Efficiency Ordinance (Cap. 610)
- Fire Aspects
  - Fire Services Ordinance (Cap. 95)
- Noise
  - Sources & Attenuation HTM 08-01 'Acoustics'
- Others
  - Building Ordinance (Cap. 123)
  - Electricity Ordinance (Cap. 406)
  - Public Health and Municipal Services Ordinance (Cap. 132)

END

https://www.orphf.gov.hk//files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf