

Engineering considerations in clinic design management

診所工程設計管理的注意事項

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2. Healthcare engineering settings in clinics for:
 - Electricity supply
 - Ventilation and air-conditioning
 - Medical gas supply
 - Special fire service installation
 - Plumbing installation
3. General advice



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Introduction

- Existing building facilities (e.g. in commercial / composite buildings)
 - Requirements for general and commercial use in premises
 - Incorporated trade practice
 - Not specific for healthcare use
- Engineering settings specifically for healthcare use
 - Infection control
 - Life support
 - Special / supplementary building services provision, e.g. back-up power, specific ventilation flow rate

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Electricity supply for healthcare facilities

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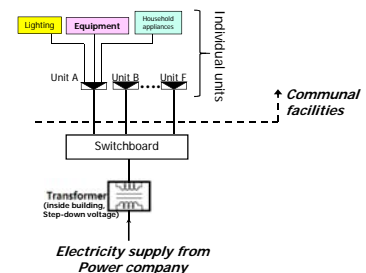
Electricity supply for healthcare facilities

- Many healthcare premises will require resilience of the internally distributed electrical installation, which should be provided according to the clinical risk assessments.
- Power outage / interruption not uncommon.
- Appropriate controls should be put in place to reduce any risk to an acceptable manageable level.
- Careful selection of a sustainable electrical supply is considered necessary for patients, staff and visitors.

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Causes of Power outage / interruption

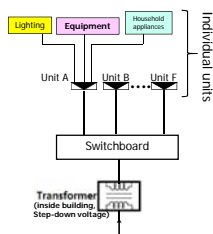
- Circuit breakdown within individual units
- Breakdown of communal electrical facilities inside a building
- Breakdown of utility network from the power company



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Causes of Power outage / interruption

- Outside building (in utilities network)
 - Power surge / voltage dip
 - Cable damage during road excavation work
- Inside building (in power distribution system)
 - Lack of electrical discrimination in engineering design
 - Electrical fault happened in central plant, such as chiller, pump causing the interruption of upstream power supply



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Back-up power for healthcare facilities

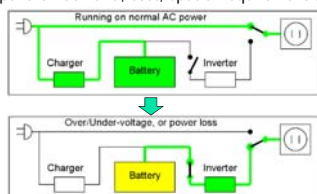
- To ensure continuous operation of life support system and safe completion/cessation of operation procedures during disruption of normal source.
- Sources
 - Biomedical equipment built-in battery
 - Uninterruptible Power Supply (UPS)
 - Emergency power generator



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Back-up power for healthcare facilities

- Uninterruptible Power Supply (UPS)
 - a set of equipment that serves as a buffer between a power source and the equipment (computers, servers, biomedical equipment, etc.) that requires power to operate.
 - act as an **emergency source** to supply sufficient and uninterrupted electricity (for a limited duration, i.e. back-up time)
 - depend on demand, cost, special requirement and back-up time.



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Example of power demand estimate for an operating room

- Example:

Item	Equipment	Power (approx.)
1	Surgical Lamp	300 W
4	Infusion Pump	50 W
5	Endoscopic Equipment	600 W
6	Anesthesia System	400 W
7	ECG Monitoring System	100 W
8	Electrosurgical Unit	150 W
Total		1600W (take 2000VA)

- Under this circumstance, at least a 2 kVA UPS system (and/or other alternative source) is selected for a back-up time of 30-45 minutes.
- Co-existing contingency plan of electricity suspension is required.

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Ventilation and air-conditioning for healthcare facilities

Ventilation and air-conditioning for healthcare facilities

- The supply of air to a room for clinical purposes has four main functions:
 - a. to dilute airborne contamination;
 - b. to control air movement such that the transfer of airborne contaminants from less clean to cleaner areas is minimised;
 - c. to control the temperature and, if necessary, the humidity of the space;
 - d. to assist the removal of, and dilute, waste gases where used.

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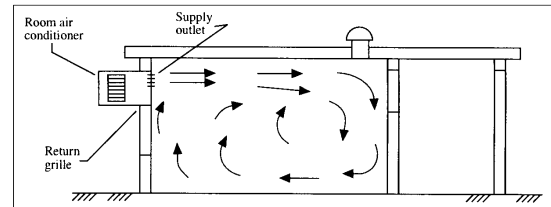
General ventilation and air-conditioning for tenancy office

- In general, mechanical ventilation and air-conditioning (MVAC) provision for tenancy office focus on:
 - Supplying fresh air (removal of indoor contaminant)
 - Maintaining thermal comfort
- Three main types of general MVAC provision:
 - Window-type air conditioner
 - Split-type air-conditioner
 - Centralised air-conditioning system (e.g. Fan Coil Unit)

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General ventilation and air-conditioning for tenancy office

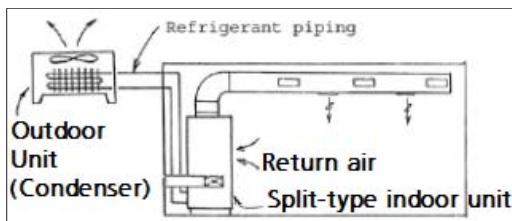
- Window-type air conditioner



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General ventilation and air-conditioning for tenancy office

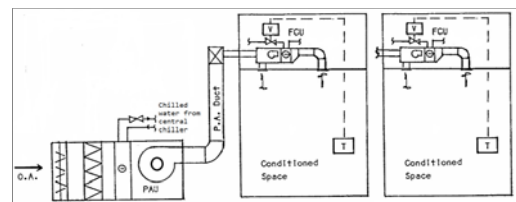
- Split-type air conditioner



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General ventilation and air-conditioning for tenancy office

- Centralised air-conditioning system (e.g. Fan Coil Unit)



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Key consideration of ventilation settings for operating room

- Operating room (OR)^{##}
 - Restricted access to support high level of asepsis control
 - Traffic limited to authorised personnel and patients
 - Designated and equipped for performing surgical or other invasive procedures requiring an aseptic field
 - Required to wear surgical attire and cover head and facial hair, and masks where sterile supplies or scrubbed persons may be located

^{##} Note: reference from "Guidelines for Design and Construction of Hospitals and Outpatient Facilities 2014" published by **Facility Guidelines Institute (FGI)**, U.S.A.

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Key consideration of ventilation settings for operating room

- For OR serving day-surgery purpose, "specialised ventilation" serves to -
 - Remove contaminant by ventilation air change
 - maintain a pressure differential between the operating suite and the adjacent area(s)
 - maintain appropriate temperature and humidity level

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Healthcare Ventilation and air-conditioning

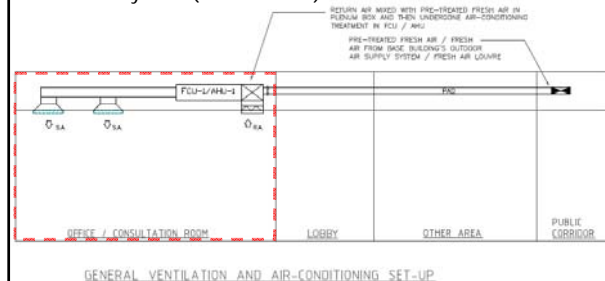
- Key differences of ventilation between common office setting and operating room

Aspect	Ventilation for office use	Ventilation for operating theatre
1 Aim	Thermal comfort and fresh air supply for occupant	Infection control, including contaminant removal, airborne protection
2 Fresh air supply	In terms of fresh air rate per person , e.g. 10 L/s/person (according to EPD's Guidance Notes)	In terms of air change rate , e.g. 15 air change per hour for day-case operating theatre (according to Health Technical Memorandum 03-01)
3 Pressure requirement	No specific requirement (slightly positive to prevent infiltration from lavatory/outdoor)	Positive (theatre → adjacent area)
4 Filtration	Comparatively lower class for dust removal	Comparatively higher class for removal of airborne particulate, e.g. HEPA for operating theatre

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Conventional ventilation and air-conditioning provision in office

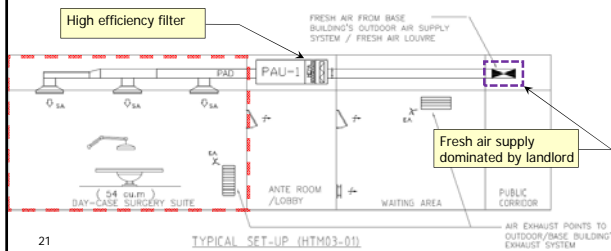
- Example: Centralised ventilation and air-conditioning system (Fan Coil Unit)



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Specialised ventilation setting for OR Option 1: No recirculation

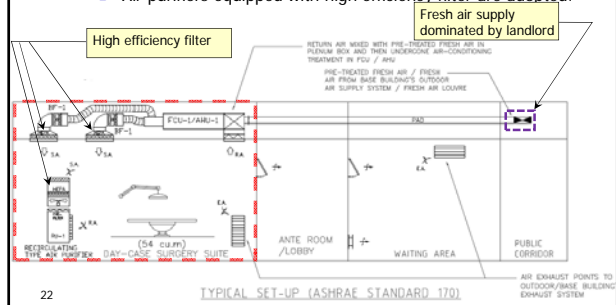
- Reference guideline/code: HTM 03-01, U.K.
- Total fresh air supply system equipped with high efficiency filter
- Apply when adequate amount of fresh air can be directly extracted from external louvre / window / landlord's duct shaft



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Specialised ventilation setting for OR Option 2: Partial recirculation

- Reference guideline/code: FGI / ASHRAE Standard, USA
- Air purifiers equipped with high efficiency filter are adopted.



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Ventilation and air-conditioning for healthcare facilities

- Key consideration for choosing different ventilation design option for OR
 - Area (and volume) of surgical suite
 - Landlord's ventilation & air-conditioning provisions, e.g. pre-treated air available? local fresh air intake/exhaust?
 - Cost (design cost, capital cost, recurrent cost)



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Medical gas supply

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Medical gas supply

- Three kinds of medical gas supply set-up commonly found in healthcare facilities
 - Central medical gas pipeline system (MGPS), mainly in hospitals
 - Medical gas cylinder
 - Oxygen concentrator



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Medical gas – certifications / standards

- Medical gas cylinder
 - HTM 02-01/2022 and Ph. Eur. (for gas quality)
 - BS EN 1089-3 & BS EN ISO 407:2004 (for cylinder's colour code and batch label of cylinders)
- Oxygen concentrator
 - CFR (Code of Federal Register) under FDA and/or 93/42/EEC under European Economic Community
 - HTM 02-01/2022 and Ph. Eur. (for gas quality)

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Medical gas – certifications / standards

- O₂ cylinder vs O₂ concentrator
 - Gas concentration:

Gas and source	Paramagnetic oxygen analyser reading
Oxygen from liquid or cylinders	Minimum 99.5%
Oxygen from concentrator	Minimum 94.0%

(source: HTM02-01, U.K.)

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Medical gas – certifications / standards

- O₂ cylinder vs O₂ concentrator
 - Quality specifications of other contents

Gas and source	Oil	Water	CO	CO ₂	NO and NO ₂	SO ₂
Oxygen from bulk liquid or cylinders	–	≤67 vpm (≤0.05 mg/L, atmospheric dew-point of –46°C)	≤5 mg/m ³ ; ≤5 ppm v/v	≤300 ppm v/v	–	–
Oxygen from PSA plant [concentrator]	0.1 mg/m ³	≤67 vpm (≤0.05 mg/L, atmospheric dew-point of –46°C)	≤5 mg/m ³ ; ≤5 ppm v/v	≤300 ppm v/v	≤2 ppm v/v	≤1 ppm v/v

(source: HTM02-01, U.K.)

** Note: The quality of the gases delivered at the terminal units should also comply with the specifications given in the current edition of the Ph. Eur.

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Special fire service installation



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Special consideration of fire service installation for critical area

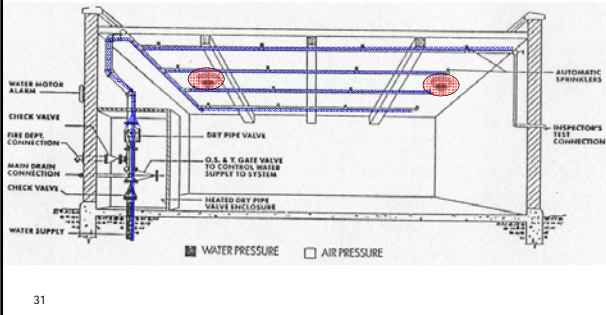
- Operating room
- Infection control concern: Wet pipe may cause water spray (or leakage) to the critical space underneath.
- Special system adopted: Conventional sprinkler installation replaced by "Pre-action sprinkler system"



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Special fire service installation

- Diagram of Pre-action sprinkler system:



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Plumbing installation

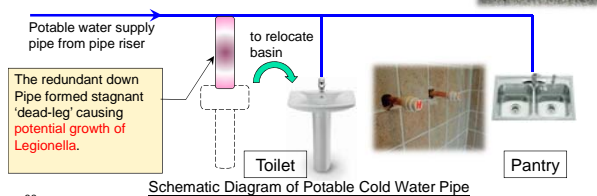
- Concerns in plumbing installation in healthcare premises
 - Legionella outbreak
 - Pipework dead-leg concern
- Two major building services components linked to the potential growth of Legionella
 - Cooling Tower
 - Redundant potable cold water pipe or hot water pipe causing stagnant water (namely Dead-leg)

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Plumbing installation

- Case Study – Alternation of potable water pipe in a healthcare institution

- Renovation / Refurbishment was conducted quite often due to the expansion or change of services.
- Redundant down pipe was left but covered by wall finishes.



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General advice for setting up clinics facilities

- Select appropriate premises to suit the operational needs
- Seek professional advice in the design of facility w.r.t. appropriate standards / codes / guidelines
- Establish a contingency plan



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Appointment of professional / agency

- References / examples
 - Registered Professional Engineer (RPE): Engineers registration board [Discipline: Electrical, Mechanical, Building Services]
 - Enquiry with professional associations
 - List of consulting firms: Building Services Category (Band 1 / Band 2) in Architectural and Associated Consultant Selection Board (AACSB), Government of HKSAR



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